

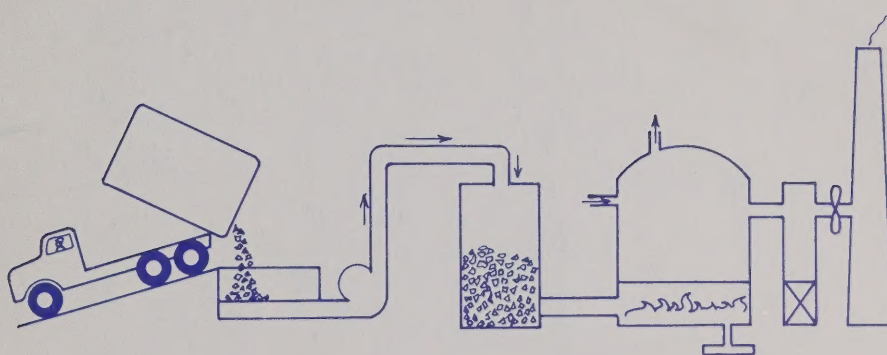
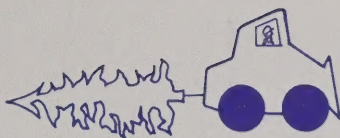
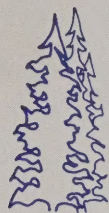
ENERPTIONS

Continued
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Introducing ENEROPTIONS:

This ENEROPTIONS file folder contains a series of case studies on demonstrations of **Wood Residue Burning** technologies. Each case study outlines the benefits, costs, payback period and nature of the demonstration as well as the operating experience, technical details, supplier information and appropriate applications of the particular technology. These case studies provide sufficient real-life information for you to assess whether the technology is applicable to your own situation. Contact people to assist you in this process or in actual implementation of the technology are listed at the end of each case study.

You will also find an overview paper entitled **WOOD RESIDUE BURNING for Space and Water Heating** in this ENEROPTIONS file folder. This overview paper integrates the collective experience of project managers, technical experts and government officials involved in the various demonstrations that are applicable to this sector. The paper draws together the vital lessons learned from these demonstrations — lessons that will greatly benefit future users of the technology. In addition, the overview paper recommends certain steps that should be taken in applying these technologies to your situation.

This ENEROPTIONS file folder provides a convenient method of storing and retrieving information on energy conservation and renewable energy options relevant to your business. Use it to file the ENEROPTIONS materials as well as other energy-related information you obtain. All ENEROPTIONS materials can be photocopied and passed on to other interested parties. Additional file folders on a range of subjects are also available free of charge.

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ENERPTIONS

OVERVIEW PAPER

WOOD RESIDUE BURNING
for Space and Water
Heating

actual implementation of the
case study.

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BURNING for Space and Water He.
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OVERVIEW
WOOD RESIDUE BURNING
for
Space and Water
Heating

1. INTRODUCTION

Many industrial, commercial and institutional establishments with significant space and water heating demands can cost-effectively meet their needs by substituting wood fuel for oil and, in some cases, electricity. Wood fuel substitution is even more cost-effective in some industrial processes which use heat and steam. Hospitals, nursing homes, schools, office buildings, apartments, industries and greenhouses have all proven to be well-suited to the application of this technology. The viability of switching to wood depends on a local and assured supply of wood or wood residues, often from sawmills, other wood products or forest harvesting operations. Where this condition can be met, the economics and reliability of wood fired boilers are very attractive.

Valuable lessons can be learned about these technologies from projects supported under the Conservation and Renewable Energy Demonstration Agreements (CREDA), the Forest Industry Renewable Energy (FIRE), and the Bioenergy Development (BDP) programs in companies and institutions across Canada.

2. WOOD FUEL PROJECTS

The projects outlined below cover the application of wood burning technology to a wide range of users in locations from the Yukon to Newfoundland. A more detailed description of each project is provided in the ENEROPTIONS Case Studies in this package.

- ONT 48 Automatic Wood-Fired Boiler - Grenville Christian College, Brockville, Ontario

A large automatic wood-chip boiler was installed at Grenville Christian College to provide all space heating and hot water requirements. The savings realized by the college are \$75,000 per year. They have planted poplar to provide for their requirements in perpetuity.

- NB 54 Wood Residue Fuelled Boiler - University of New Brunswick, Fredericton, New Brunswick

A large wood-fired boiler was installed, under an innovative savings financing arrangement, at the district heating plant which serves the entire UNB-Fredericton Campus, two apartment buildings, and a large hospital. Annual operating savings in the range of \$820,000 are being realized as the contribution to total heating requirements is over 70%.

- NWT 21 Wood Heating of Fort Smith Water Supply - Fort Smith, N.W.T.

The town's water supply is now heated by an automatic-feed wood-fired hot water boiler unit. Fuel wood for the boiler is harvested locally creating a new industry and new jobs. The project resulted in the displacement of 160,000 litres (35,195 gallons) of fuel oil in its first year and is expected to displace approximately 200,000 litres in subsequent years.

- ONT 34 Energy from Wood Waste - Foothill Greenhouse Ltd., Kettleby, Ontario

A system which burns wood chips and sawdust provides all heating requirements and results in energy savings of \$46,580 annually by replacing oil. Heating, ventilation and humidity are controlled and monitored by a microcomputer, which reduces



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manpower needs.

- NFLD 31 Wood-Chip Heating - Newfoundland Hardwoods Ltd., Clarenville, Newfoundland

An asphalt and creosote plant replaced its oil burning system with a medium-scale wood burning system. Approximately 1,365,000 litres (300,000 gallons) of oil have been displaced resulting in an annual savings of \$118,800.

- NB 10 Modifications to Wood-Chip Boiler - Maritime Forest Ranger School, Fredericton, New Brunswick

The existing wood-chip boiler system was modified and updated to improve efficiency, reliability and safety and to expand the range of cull wood it could use. Wood costs have thus been cut by 65% per year.

- NB 22 Wood-Chip Burner - Brookdale Nurseries, Newcastle, New Brunswick

Wood chips are now being used to fire boilers originally designed for oil at the Brookdale complex which includes greenhouses, retail display area, farmers market, office, maintenance and stock areas. Annual savings of \$30,000 in fuel costs have been realized.

- YUK 17 Pelly Crossing Wood-Chip Furnace Project - Pelly Crossing, Yukon

Space heating and domestic hot water for the community's new 1,300 m² (14,000 ft²) school is provided by an automatic-feed, wood-chip boiler. Fuelwood for the boiler is harvested locally. Savings are \$11,425, or 60% of the cost of operating a conventional, oil-fired system.

NFLD 3 Hospital Wood-Fired Boiler - Gander, Newfoundland

A 160-bed hospital saves \$100,000 annually by using wood residue in a Canadian wet cell burner.

QUE FIRE Sawmill Wood Residue for Lumber Drying - Beloeil, Quebec

A Quebec sawmill saves over \$100,000 and 830,000 litres (182,500 gallons) of oil a year by using their sawmill residue to heat their lumber drying kilns, thus solving both energy and waste disposal problems.

BC BDP Reliable Biomass Bin-Feeder - BCR/UKAF, Vancouver, B.C.

To eliminate flow stoppage, a major problem in the use of biomass residue fuels, B.C. Research has designed a bin feeder system that has close to half the capital costs and less than one-third the operating costs of conventional storage and recovery systems.

Many other wood burning projects have been undertaken. Contact your nearest federal or provincial energy office to learn more about nearby projects or those applications similar to yours.

3. LESSONS LEARNED

All of the above projects demonstrated the direct combustion of wood, usually in the form of wood chips, in a boiler to provide hot water for space heating and water heating purposes.

Important lessons were learned, especially with respect to quality control and ensuring that all system components are in place.

Payback Period. The demonstrations showed that the burning of wood is a very cost-effective alternative to the use of oil for heating purposes. Payback periods for conversion to wood-fired boilers amongst the CREDA projects range from 3 to 12 years.

Quality Control. Careful control of wood fuel quality is essential to high efficiency and low maintenance costs. Contamination of fuel by soil, stones, glues, coatings, nails, or excessive moisture content can cause handling, combustion and emissions problems. Excess clinker build-up has been a problem in some installations. This can probably be corrected by improved fuel quality control (i.e., fewer contaminants) and a slight over-firing of air. Creosote build-up in dust collectors and stacks has also been experienced, especially at low-load and when fuel moisture content is high. This can often be reduced by excess air and higher capacity operation.

Emissions. In converting from oil to wood, sulfur dioxide emissions cease, but oxides of nitrogen and particulates may increase. If the design includes induced draft, ash scrubbers and separators and if the burn is properly regulated, fewer pollutants are emitted from wood than oil. The production of polycyclic hydrocarbons is also an area of concern and debate but more in relation to damped-down residential wood stoves.

Fuel Handling Systems. Materials handling systems (conveyors, storage bins, augers, feeders, etc.) are probably the most trouble-prone part of the system and require careful attention to their design, operation and maintenance. Uniform fuel - size, shape, moisture content - is especially important to efficient materials handling, which can in turn affect choice of equipment and thus cost.

On-site Storage. Sufficient on-site storage capacity is required to cover periods of peak demand and possible problems in the supply line. Generally, this is a maximum of four days for industrial operations.

Operation and Maintenance. Wood burning boilers require more maintenance and closer attention than oil-fired systems which may mean higher labour costs. These are usually offset by lower fuel costs.

Ash Disposal. An advantage of using residue fuel is that it leaves minimal ash, though disposal must also be considered. Collection and tipping fees should not be overlooked.

4. NEXT STEPS

If you are considering an alternative heating system, it is important to take the following steps:

- assess your heat requirements in terms of seasonal duration, temperatures, peak loads, and cost and practicality of alternatives;
- arrange for a long-term reliable supply of wood, wood residue, wood chip or sawdust fuel and obtain a written guarantee of delivery and price, at the same time ensuring that you have sufficient flexibility to capitalize on short term options;
- locate a consultant and contractor experienced in woodburning systems who can provide information on wood storage, feeding and burning equipment and who can accurately size the equipment for the reduced heat load after application of cost effective conservation;
- where capital cost of the system is a barrier, consider a savings financing arrangement whereby an outside party finances the costs and is repaid out of the institution's savings over a period of time. Such arrangements can also include operation and maintenance of the equipment. The other party is often either the consultant, equipment supplier or fuel supplier.

5. RESOURCES AVAILABLE

Technical reports are available free of charge for most of the CREDA projects listed above. Addresses of appropriate contacts for follow-up, including equipment suppliers and system designers, are listed at the end of each of the attached ENEROPTIONS case studies under the "Further Information" section.

The departments or ministries of energy in each province or territory have information on energy conservation and renewable energy and may have assistance programs. Check your telephone directory for appropriate contacts.

The Conservation and Renewable Energy Offices (CREOs) of Energy, Mines and Resources Canada in each province and territory have information on converting to wood, such as technical bulletins, data bases on projects, equipment suppliers and wood availability as well as on demonstrations and other assistance programs. Check the back of the attached file folder for the office in your area.

Information on qualified engineering firms by area of specialization and the "Recommended Procedure for the Selection of an Engineer to Provide Professional Services" can be obtained from:

(a) The Association of Consulting Engineers of Canada
Suite 616
130 Albert St.
Ottawa, Ontario
K1P 5G4
(613) 236-0569

(b) The consulting engineering organization in your province.

Information on innovative financing arrangements may be obtained through the government sources listed above or by contacting:

Martin Adelaar
(Re: ENEROPTIONS)
Energy Management Advisor
Energy Conservation and Oil Substitution Branch
Energy, Mines and Resources Canada
580 Booth Street
Ottawa, Ontario
K1A 0E4
(613) 995-1118

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Reliable Bin-Feeder Design for Biomass Materials

B.C. RESEARCH—VANCOUVER, BRITISH COLUMBIA

Technology:

Storage and flow of biomass

Project Manager:

Nazmir Bundalli, P. Eng.
Senior Engineer
B.C. Research
3650 Wesbrook Mall
Vancouver, B.C.
V6S 2L2

Location:

Vancouver, B.C.

Savings:

Half or less of the capital cost and less than one-third the operating cost of conventional storage and recovery systems.

Additional savings from improved reliability.

Applicable to:

Industrial, commercial and institutional storage and recovery of: hog fuel, wood chips, sawdust, shavings and other forms of wood residues for fuel.

Description:

An improved bin-feeder design has been developed to eliminate flow stoppage, a major problem in the use of biomass residue fuels. The design utilizes a converging, mass flow hopper with outlet dimensions in the range 0.8 m (2.6 ft) to 1.5 m (5 ft), depending on the flow characteristics of the material to be stored as well as storage conditions.

The discharge feeder is designed to promote flow over the full length of the outlet slot and to reduce or eliminate stress build up and compaction of the material at the front vertical wall, a major cause of bridging.

Multiple screw, chain or belt feeders are used for slot lengths up to 8 m (26 ft). The 8 m limit on the length is necessary due to the difficulty in feeding uniformly over longer openings. A new discharge feeder currently being developed will not have this length limitation. The bin-feeder design allows reliable and uniform flow under gravity alone, without the need for flow promoting devices.



Energy efficient belt feeder.

Benefits:

- Eliminates stoppages in flow which are disruptive to production.
- Uniform, first-in-first-out flow results in consistent quality of feed to energy conversion or processing system.
- Converging hopper design reduces stress on the discharge feeder as well as simplifying its design and lowering its power requirements.
- A reliable and economical bin-feeder system is achieved.

Performance:

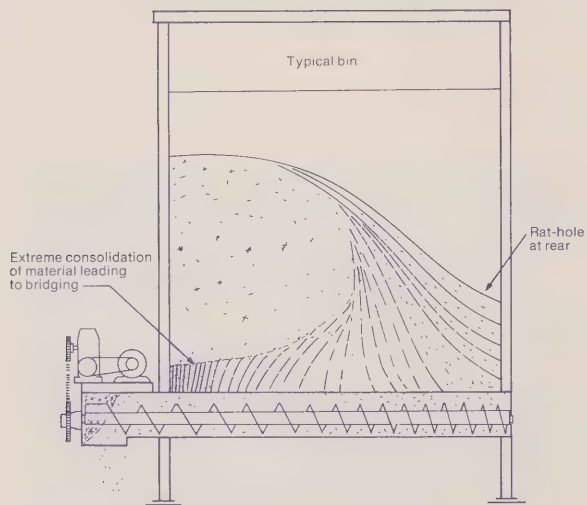
The bin-feeder design principles have been demonstrated on an 80 m³ (2,825 ft³) capacity bin located at B.C. Research. The first series of tests were done without a discharge feeder in order to confirm the outlet dimensions and hopper slopes independently of the feeder performance.

- Hog fuel and wood chips were found to flow easily through a converging hopper with outlet dimensions that were very practical and much smaller than those commonly used.
- Flow was feasible even for the worst flowing hog fuels (e.g., stringy cedar bark) after prolonged periods of storage at rest.

Technical Details:

Extensive laboratory evaluations were carried out on specially constructed equipment during 1981/82.

- A major problem with biomass was found to be its enormous resistance to funnelling (or “flowing over itself”). Hopper design that relies on the material flowing through the centre core of the bin cannot work.
- With a mass flow hopper design (characterized by smooth, steep hopper walls), flow under gravity alone was found to be feasible. Outlet dimensions predicted were quite practical and much smaller than those commonly used.



Typical Discharge Feeder Problems

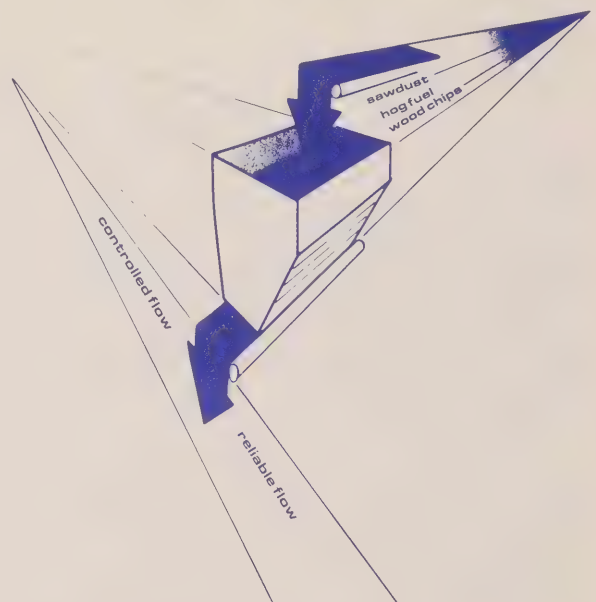
Initial tests with a multiple screw discharge feeder ran into severe bridging problems which resulted from poor feeding. These problems were overcome by improving the flow through the full 5 m (16 ft) long slot. A major problem that had to be overcome was the lack of movement and compaction of material at the front vertical wall.

- Power requirements of the feeder decreased substantially with improved feeding.
- It was concluded that excessive power input at the feeder, if applied improperly, is a major cause of bridging.

A simple belt feeder consisting of a smooth belt on a flat deck was subsequently operated with a 1.1 kW motor.

- Hopper slopes necessary for mass flow were found to be very steep and, hence, impractical for most situations with conventional bin wall materials (concrete and steel). Special lining materials were found to be necessary.
- High molecular weight polyethylene and glass-coated steel surfaces were found to have sufficiently low wall friction to allow reasonable hopper wall slopes.

The above laboratory findings were confirmed on an industrial size bin. The discharge feeder was found to be a key component and required considerable attention to assure uniform flow over the full opening.



- bin & feeder designed as an integral unit
- relies only on gravity for flow
- eliminates consolidation from poor hopper and/or feeder design
- substantial power savings
- design adaptable to capacity and plant layout

Economic Analysis:

The following table compares two common bin feeder systems to a BC Research /UKAF unit of the same capacity, 25 units or 140 m³ (5,000 ft³).

	Bin Feeder System		
	Stoker	Travelling Screw	BCR/UKAF
Installed Cost of Bin	\$ 70K	\$ 80K	\$110K
Discharge Feeder	\$260K	\$190K	\$ 40K
Drive Motor, Controls And Wiring	\$ 70K	\$ 30K	\$ 10K
Motors Required	4-60 hp	1-60 hp	1-25 hp
	1-5 hp	1-5 hp	
Total Installed	\$400K	\$300K	\$160K
Annual Costs			
Power (\$200/hp)	\$ 25K	\$ 13K	\$ 5K
Maintenance (10% of feeder cost)	\$ 26K	\$ 19K	\$ 4K
Total Annual O&M	\$ 51K	\$ 32K	\$ 9K
Reliability	Poor	Fair	Good

Thus, the new B.C. Research/UKAF bin feeder design offers a more reliable installation at almost half the cost and less than one-third the operating cost of the closest alternative.

Availability:

The research was carried out by B.C. Research in Vancouver, British Columbia. UKAF Canada, a Vancouver-based company, provided considerable practical input. B.C. Research and UKAF can assist with evaluations and

engineering for new bin-feeder systems or improvement of existing ones. A large pulp and paper company is presently making modifications using this design.

Further Information:

Further information and copies of technical reports are available from:

- ENEROPTIONS
Bioenergy Development Program
Renewable Energy Division
Energy, Mines and Resources Canada
580 Booth Street
Ottawa, Ontario
K1A 0E4
(613) 995-9447

For information on application of the research, contact:

- B.C. Research
3650 Wesbrook Mall
Vancouver, B.C.
V6S 2L2
(604) 224-4331
Attention: Mr. Nazmir Bundalli
(re: ENEROPTIONS)
 - UKAF Canada
Division of Skeath Materials Handling Ltd.
1250 Homer Street
Vancouver, B.C.
V6B 2Y5
(604) 681-1847
Attention: Mr. David Skeath
(re: ENEROPTIONS)
-

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Sawmill Wood Residue for Lumber Drying

LE BOIS FRANC ROYAL HARDWOOD LTÉE. — BELOEIL, QUÉBEC

Technology:

Wood residue combustion

Annual Savings: \$112,000

Payback Period: 4.5 years

Project Manager:

Pierre Legault
President
Le Bois Franc Royal Hardwood Ltée.
2095 rue de l'Industrie
Beloeil, Quebec
J3G 4S5

Applicable to:

Industrial, commercial and institutional users of low pressure steam which have access to wood residues:

- Sawmills
- Wood products
- Institutions
- Greenhouses
- Various industries

Location:

Beloeil, Quebec

Description:

By burning its waste wood to heat its lumber drying kilns, a Beloeil, Quebec sawmill solves both energy and waste disposal problems.

Le Bois Franc Royal Hardwood Ltée. fabricates wood components used in the manufacture of furniture and

cabinets. The project involved the conversion of an oil-fired boiler to a wood waste fueled boiler to provide heat to dry lumber. The equipment consists of a Volcano wood waste boiler and ancillary equipment to condition, transport and store the fuel.

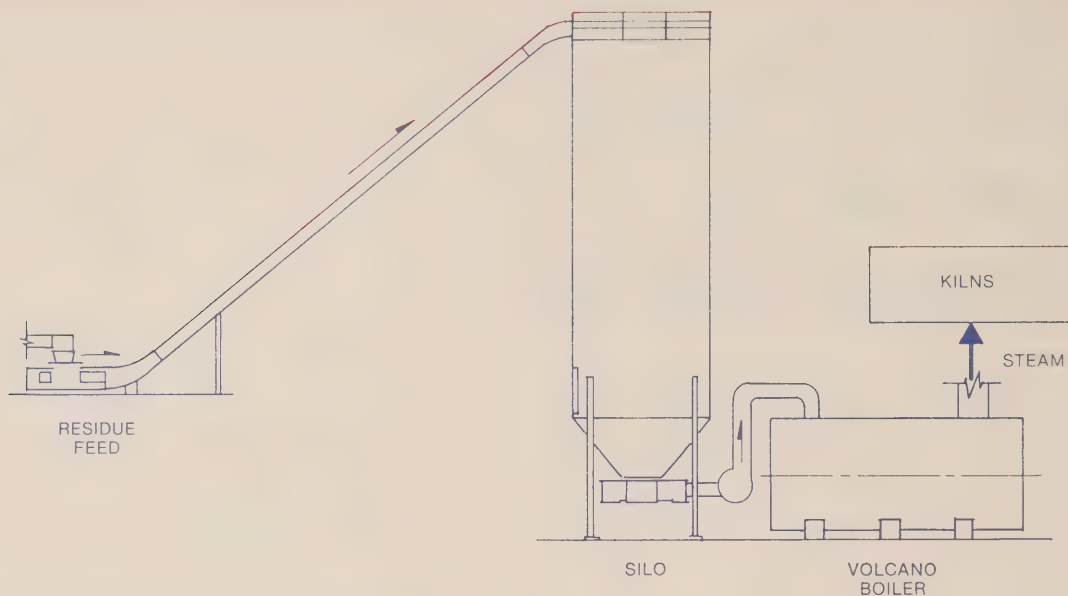
Benefits:

- The company reduces its oil requirements by 830,000 L (182,580 gals) per year.
- The system helps to reduce the environmental problem of disposing of wood wastes as landfill.
- Net savings in heating costs reach \$112,000 per year.

Technical Details:

The company produces about 5 tonnes (5.5 tons) of sawdust and fine residue daily from machining of wood and another 17 tonnes (19 tons) in the form of blocks, which can be passed through a hammer mill to reduce them to size

required for fuel. This residue feeds a Volcano furnace at the rate of 8.8 tonnes (9.7 tons) per day to produce 6,800 kg/hr (15,000 lbs/hr) steam at 105 kPa (15 psig). The steam is used to dry lumber in the kilns.



Bois Franc Royal Hardwood

Economic Analysis:

	(1981 \$)
Equipment Cost:	\$500,000
	(1981 \$)
Annual Fuel Savings	\$130,000
Operating and Maintenance Costs	(\$18,000) approx.
Net Annual Savings	\$112,000

Payback Period: 4.5 years.

Availability:

The combustor and steam generator were supplied by Volcano Inc. of St-Hyacinthe, Quebec. This company offers turnkey installation in the sizes ranging from 5 to 250 GJ/hr (4.7 to 237 MBtu/hr) which includes the fuel handling,

storage, feeding, combustion, controls and flue gas cleaning equipment. Similar equipment and services are available from suppliers across Canada.

Further Information:

For further information, contact:

- Pierre Legault
 (re: ENEROPTIONS)
 President
 Le Bois Franc Royal Hardwood Ltée.
 2095 rue de l'Industrie
 Beloeil, Quebec
 J3G 4S5
 (514) 467-9271

- ENEROPTIONS
 Renewable Energy Division
 Energy, Mines and Resources Canada
 580 Booth Street
 Ottawa, Ontario
 K1A 0E4
 (613) 995-9447

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Wood-Fired Boiler

JAMES PATON MEMORIAL HOSPITAL

Technology:

Large-scale, direct combustion of wood residues

Annual Savings: \$100,000

More than 38% of conventional operating costs

Demonstration Project Manager:

Peter Lush, Chief Engineer
James Paton Memorial Hospital
Trans-Canada Highway
Gander, Newfoundland
A1V 1P7
(709) 651-2500

Payback Period: 10 years

Applicable to:

- Hospitals
- Nursing homes
- Universities
- Schools
- Remote communities
- Large industries in areas where there is a secure supply of wood residues.

Location:

Gander, Newfoundland

Description:

The James Paton Memorial Hospital, a 19 year-old, 162-bed institution with a heated area of 11,900 m² (128,000 ft²) has reduced both its annual heating bill and its energy consumption by replacing its old oil-fired boilers with a wood-fired Canadian Wet Cell burner. By switching from Bunker C oil to wood residue as a heating fuel, the hospital is not only saving \$100,000 per year but has also created local employment. The hospital has hired a contractor to collect wood residue from pulp log harvesting, chip it and deliver the chips to the hospital. The money spent on fuel, which previously left the community, now remains within the local area, which in turn creates further employment. The system has been operational since April 1983 with no equipment-related or other problems.



Benefits:

- Savings resulting from the displacement of Bunker C oil with wood residue have been approximately \$100,000 per year.
- The switch to wood has brought about a noticeable reduction in sulphur emissions.
- Two permanent jobs have been created in connection with the harvesting, chipping and delivery of the wood.

Performance:

The viability of burning wood to produce steam for heating has been demonstrated by this project. The wood-burner operates at an efficiency of 65%. With respect to reliability and maintenance requirements, the system is operating above expectations.

Some problems were experienced with contamination of the wood chips by dirt and rocks. These caused damage to the fuel-loading system and an excessive amount of clinker in

the ash. The contamination, which was caused by storing the chips on the ground, disappeared when this practice was stopped. There have been no problems with wood truck noise or with ash disposal.

While maintenance cost figures are not yet available, experience to date indicates that costs will likely be comparable to those associated with an oil system.

Technical Details:

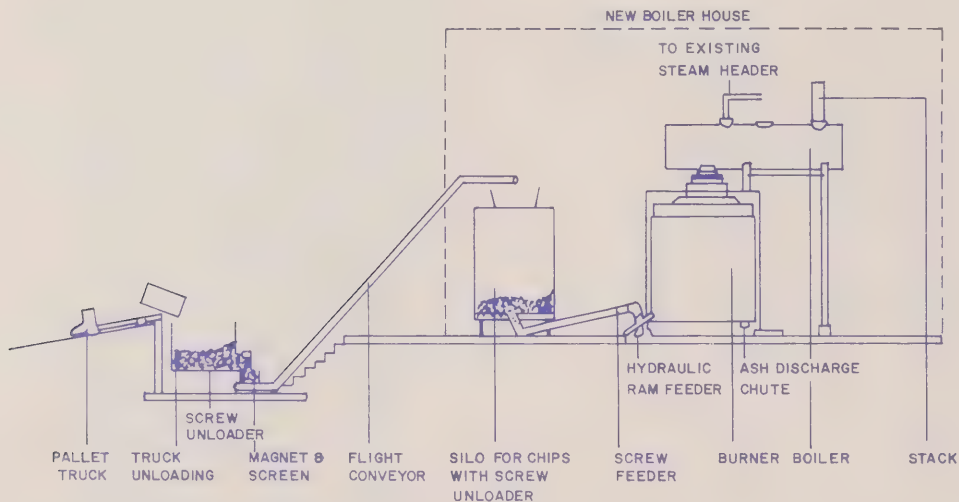
Prior to the installation of the wood-burning system, the steam supply of the hospital was produced by two 250 hp Powermaster oil-fired steam boilers. They normally operated at an output of between 1,360 to 2,720 kg steam per hour (3,000 - 6,000 lbs/hr) at 690 kPa (100 psi) and 164° C (327° F).

The burner selected for the project was a Canadian-designed 1.8 MW Lamb Cargate Wet Cell burner, the most efficient but also the most expensive of the units considered. The burner was housed in an extension built on the boiler house to protect it from the harshness of the Newfoundland environment, specifically high relative humidity and high salt content in the air.

The wood chips are supplied to the hospital by Central Forest Products. Waste logs are collected from pulp mills, chipped using a Morbark Eager Beaver Chipper and delivered to the hospital by truck.

When the wood chips are delivered they are dumped into an unloading hopper and moved by screw-type conveyors to a 5 cm (2 in) mesh vibrating screen. Once through the screen, the chips pass by a magnet, (which removes metal objects) and are loaded into a 50,650 cm³ (3,091 in³) storage silo. The silo holds enough chips to fire the burner for two days.

The chips are then moved by a sweep auger in the silo into a discharge hopper, which feeds them into a variable speed screw to be loaded into a ram feeder. The mechanism to transport the chips from the silo to the burner was supplied by Laidig Inc. The feed screw and the ram feeder, which push the chips into the bottom of the burner, are controlled by the burner combustion control system. The ashes are discharged by a conveyor to barrels located outside the boiler house.



Material flow diagram for James Paton Memorial Hospital, Gander, Nfld.

Economic Analysis:

Capital Cost Summary

Equipment (loading devices, burner/boiler unit, chipper, etc.)	\$421,460
Other (boiler house extension, installation burner/boiler installation loading devices, etc.)	\$586,540
Total	\$1,008,000

Annual Operating Cost Savings

Oil-fired system cost	\$260,000
Wood-fired system cost	(\$160,000)
Savings	\$100,000

Payback Period

$$\frac{\$1,008,000}{\$100,000} = 10 \text{ years}$$

NOTE: The payback period was longer than expected because the most expensive burner was chosen and cost overruns resulted from lack of experience with this type of installation.

Availability:

The burner was supplied by:
Lamb Cargate
P.O. Box 440
1135 Queens Ave.
New Westminster, B.C.
V3L 4Y7

The silo unloading system was supplied by:
Laidig Inc.
1320 South Merrifield
Mishawaha, Indiana 46544
U.S.A.

The chipper was supplied by:
Morbark Industries
P.O. Box 1000
Winn, Michigan 48896
U.S.A.

The chips were supplied by:
Central Forest Products
247 Elizabeth Drive
Gander, Newfoundland
A1V 1J3

Further Information:

For further information and a copy of the final technical report, contact:

- Energy Branch
Department of Mines and Energy
Government of Newfoundland and Labrador
P.O. Box 4750
St. John's, Newfoundland
A1C 5T7
(709) 576-2411

The project manager and system owner is:

- Peter Lush, Chief Engineer
(re: ENEROPTIONS)
James Paton Memorial Hospital
Trans-Canada Highway
Gander, Newfoundland
A1V 1P7
(709) 651-2500

Pelly Crossing Wood-Chip Furnace

Technology:

Automatic wood-chip boiler

Annual Savings: \$11,425

60% net savings on cost of oil heating

Demonstration Project Manager:

Mr. Al Fedoriak
Maintenance Division
Department of Education
Government of Yukon
P.O. Box 2703
Whitehorse, Yukon
Y1A 2C6
(403) 667-5143

Payback Period: 11 years

Applicable to:

Space and hot water heating applications in remote communities —

- Schools
- Hospitals
- Commercial buildings

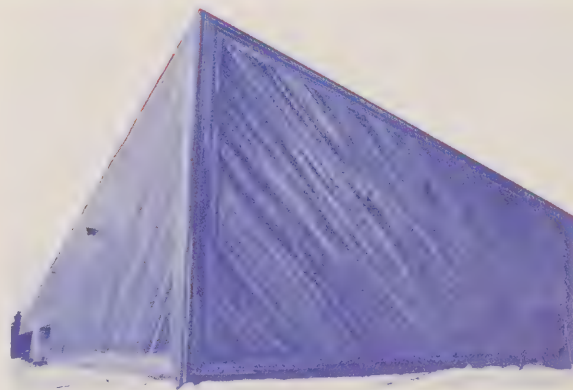
Location:

Pelly Crossing, Yukon

Description:

A wood-chip heating system in the new school is saving oil and money, utilizing a local resource and providing employment in Pelly Crossing — a small, relatively isolated and predominantly native community approximately 280 km (175 miles) north of Whitehorse, Yukon.

In 1980, approval was received to build a new 1,300 m² (14,000 ft²) school which was also to serve as a community and recreation center. In the original design, the Eliza Van Bibber School was to be heated by two oil-fired boilers. However, in the final design stage a wood-chip heating system, providing both space heat and domestic hot water, was selected as a substitute for the oil system. The biomass system consists of a 350 kW Vyncke wood-chip boiler, an underfed stoker, and a 50 m³ (1,765 ft³) silo. Chips are provided from local fire-killed wood using a Bruks wood chipper powered by a diesel tractor. Backup is provided by a boiler and a domestic water heater, both fired by propane.



When the Government of Yukon constructed this new school for the community of Pelly Crossing it chose wood chips as the fuel source.

Benefits:

- The net annual savings from the wood-chip heating system appear to be \$11,425 (1984), equivalent to 60% of the cost of operating a conventional, oil-fired system.
- The wood-chip heating system provides significant local economic benefit. Local cordwood is purchased from

the Selkirk Indian Band at \$60/cord — approximately 1/3 of the equivalent cost of fuel oil. Money formerly spent outside of the community for fuel oil is now spent within the community and provides an important local economic stimulus.

- The harvesting and chipping of wood has created two local part-time jobs in a community of about 200 plagued by chronic unemployment.
- Both the local wood fuel supply and the wood-chipping system have considerable unused capacity. Further applications of wood-chip heating, as a substitute for conventional oil heating, are being pursued within the

community. When implemented, these will further contribute to the local economy by reducing fuel costs, increasing local disposable incomes and creating additional employment.

Performance:

The system is now operating consistently and efficiently. Performance data are being collected and the results of a complete year's operation will be available by June 1985.

The approximate price of delivered heat from fuel oil (@ \$0.46/litre) was estimated to be \$20.10/GJ, or \$19,295 annually (1984). Preliminary estimates indicate that the comparable cost using local wood chips is \$8.20/GJ, or \$7,870 annually based on: \$60/cord for the harvested wood; \$1,500 for labour and \$450 for operation and maintenance of the chipper; \$1,000 for propane backup; and \$120 for electricity to power the augers. The 1984 net savings are therefore estimated at \$11,425.

During the first few months of operation, a variety of technical problems were encountered. Although the problems were relatively minor they were exacerbated by the lack of technical services available within the community and by the community's remote location. Technical problems were encountered in the following areas:

- wood chip blockages in the auger system
- excessive exhaust fan noise
- system controls

In its initial operation, frequent blockages occurred at the first transfer point in the auger system. These blockages occurred as a result of oversized chips or splinters and the design of the transfer point. During one such incident, the auger itself was damaged. The blockage problem at the first transfer point was overcome by replacing the original corrugated metal sleeve with an angled sleeve made of metal on three sides with a plexiglass front. Greater attention was also paid to achieving uniform chip size. A slip clutch was also installed to prevent damage to the auger or motor in the event of future blockages.

Excessive fan noise was remedied by decreasing the speed of the forced draft fan. This also brought the air supply more in line with optimum levels and increased the overall boiler efficiency.

One of the boiler's safety controls created a minor problem. A sensor located upstream from the exhaust fan measures the flue gas temperature and, if the exhaust temperature is too low, the sensor automatically shuts down the boiler after 25 minutes of operation. The sensor which was installed initially had too high a temperature range and caused the boiler to shut down frequently. A new sensor with a proper temperature range will eliminate the problem.

Technical Details:

The school is a 1,300 m² (14,000 ft²) single-storey building of slab floor construction (built in 1982). In the interests of thermal efficiency, it includes roof insulation of RSI 9.2 (R 52), wall insulation of RSI 3.5 (R 20) and triple-glazed windows. The designed space heating temperature is 21°C (70°F) during occupied hours and 13°C (55°F) during setback hours. The total space heating and domestic water heating requirements are about 960 GJ per year.

Local fire-killed timber is harvested as cordwood by members of the local Selkirk Indian Band and is then chipped on site using a Bruks MTH922 wood chipper powered by a 40 hp John Deere 1040 diesel tractor.

The chips are fed into a 50 m³ (1,765 ft³) underground concrete silo, which provides storage capacity for about 10 days during maximum demand periods. The silo is equipped with a heat loop (to prevent freezing) and a live bottom consisting of trapezoidal cylinders, which are pulled across the bottom of the silo by hydraulic pistons in order to supply wood chips to the first of three 30 cm (12 in) diameter fuel augers. A rotary air lock is installed at the second transfer point to prevent burn-back. Burn-back is also prevented by means of a supply of water which will flood the final auger housing should it attain unacceptably high temperatures.

The heating system — a 350 kW Vyncke model WW300S underfed wood chip boiler with automatic feed — was installed during the fall of 1982. Operation began in February 1983.

The boiler is a three-pass vertical fire tube unit, which can be fed either with wood chips through the underfed stoker, or manually with cordwood through its door. An oil burner can also be fitted to an alternate door, if desired. Draft is provided by means of a blower located at the top of the boiler immediately beyond the fire tubes. Fly ash passes from the hearth through the fire tubes and is removed in a cyclone located just beyond the blower. The blower and cyclone are constructed of heavy gauge metal to resist the abrasive action of the fly ash. The boiler is designed to operate with 80% excess air at a combustion temperature of 1,320°C (2,400°F) and with virtually 100% combustion efficiency. Efficient heat exchange is achieved both through direct radiation and through the vertical fire tubes. The exhaust gases exit the boiler at a fairly cool 150°C (300°F) and are relatively clean.

Both the air intake and auger speeds have been adjusted to deliver the maximum requirements of the building. In this manner, maximum efficiency can be achieved during the shoulder periods, when a reduced boiler output is needed. The boiler contains more than 3,000 litres (660 gallons) of water, which stores approximately 120 MJ of heat. This supplies the building's heat requirements between boiler cycles. During normal operation, the boiler runs for about 20 minutes and then shuts down until further heat is required. The hearth will maintain a fire for longer than 24 hours during periods of very warm weather.

Economic Analysis:

Capital Cost:

Vyncke Model WW300S	\$ 77,500
Warranty	3,000
Concrete silo & modifications	20,489
Glycol heat loop	4,000
DHW heat exchanger	19,226
Boiler electrical and automatic controls	14,394
Markup	7,908
Miscellaneous	4,684
Sub total:	151,201
Credit (oil boiler and propane backup):	(28,340)
Incremental capital cost for wood-chip system:	122,861
Incremental costs of boiler installation:	5,000
Total Capital and Installation:	\$127,861

Annual Operating and Maintenance Costs:

Estimated annual fuel oil savings (41,850 litres @ \$0.461):	\$19,295
Estimated (annual) wood heating cost:	
• 80 cords of wood @ \$60	4,800
• chipper operation and maintenance	450
• labour for chipping	1,500
• propane backup	1,000
• electricity for auger operation	120
	(\$ 7,870)
Net Annual Savings:	\$11,425

Simple Payback Period: 11 years.

Availability:

The system was designed, supplied and installed by Apsco Engineering. Automatic wood-chip heating systems are

available through suppliers and consulting engineering firms in major centres throughout Canada.

Further Information:

An interim technical report on this demonstration project is available from:

- ENEROPTIONS
Energy Branch
Department of Mines and Small Business
Government of Yukon
P.O. Box 2703
Whitehorse, Yukon
Y1A 2C6
(403) 667-5382

Further information on this demonstration project is available from:

- Mr. Jack Dueck
(re: ENEROPTIONS)
Apsco Engineering Ltd.
P.O. Box 270
Cremona, Alberta
T0M 0R0
(403) 264-1049
 - Mr. Al Fedoriak
(re: ENEROPTIONS)
Maintenance Division
Department of Education
Government of Yukon
P.O. Box 2703
Whitehorse, Yukon
Y1A 2C6
(403) 667-5143
-

CAI
MS 230

Wood-Chip Burner

BROOKDALE NURSERIES

Technology:

Small-scale, direct combustion of wood residues

Demonstration Project Manager:

Lloyd Brown
President
Brookdale Nurseries Ltd.
P.O. Box 422
Newcastle, New Brunswick
E1V 3M5
(506) 622-3424

Location:

Newcastle, New Brunswick

Annual Savings: Approximately \$30,000
62% of previous heating costs

Payback Period: 3 years

Applicable to:

- Greenhouses
- Food Processing
- Hospitals
- Nursing homes

Description:

Brookdale Nurseries, one of New Brunswick's largest greenhouse complexes, is now using wood chips to fire boilers originally designed for oil. Brookdale Nurseries is a .75 hectare (1.85 acre) complex consisting of 17 greenhouses, a retail display area, a farmers' market, and office, maintenance and stock areas. It was formerly heated by four 250 hp, oil-fired steam boilers and one 60 hp boiler. In late 1981, one of the large boilers was modified by replacing the original oil-burner with a Dutch Oven type combustion chamber burning wood chips. The oven is attached at the firing end of the boiler and connected by a refractory-lined collar.

Roundwood and slabs are chipped on site, stored in a day bin, and supplied to the oven by a chip handling system which is controlled automatically by the steam pressure in the boiler.

The system was designed and built largely by the owner of the Nurseries. In places, it uses equipment which was on hand and adapted to the system.

**Benefits:**

The conversion of the first boiler to wood chips has produced the following benefits:

- a net saving in fuel costs of about \$30,000 per year, or 62% of previous costs;
- reduced air emissions compared to roundwood or oil;
- local employment and income produced in supplying and chipping wood;

- maintenance of existing greenhouse jobs through a more economic operation;

The owner was so satisfied with the results on the first boiler, that he subsequently converted a second large boiler to burn wood chips.

Performance:

The wood-chip boiler was monitored for the seven months of the 1983/84 heating season and demonstrated the following performance:

- Overall fuel consumption was 420 tonnes (460 tons) of wood chips at 20% moisture content wet basis (25% moisture content dry basis).
- Total production of steam at 40 kPa (6 psig) was 2.1 million kg (4.6 million lbs).
- System efficiency ranged from 69.5% with undried chips at a low capacity factor of 45.9% to 84.6% with dried chips at a high capacity factor of 75.7%. These values were about 10% higher than expected.
- Stack emissions were quite clean, with a smoke number of 1 (cleaner than oil).
- The burner and boiler were operating at only 20 to 25% of full capacity — far below their potential.
- There were occasional jams in the fuel feed system caused by over-sized chips.

- The excess air supply to the Dutch Oven varied from 50% to a more typical 260%. This contributed to low stack temperatures and carry-over of fly ash into the boiler-tubes.

Several recommendations were made to increase the system output including:

- An increase in the fuel feed rate by doubling or tripling the auger speed;
- Installation of a fuel spreader device to obtain better fuel distribution over the grate;
- Adjustment of the combustion air supply to reduce excess air to about 50%.

To reduce the fuel jamming problems, two solutions were tried, with success:

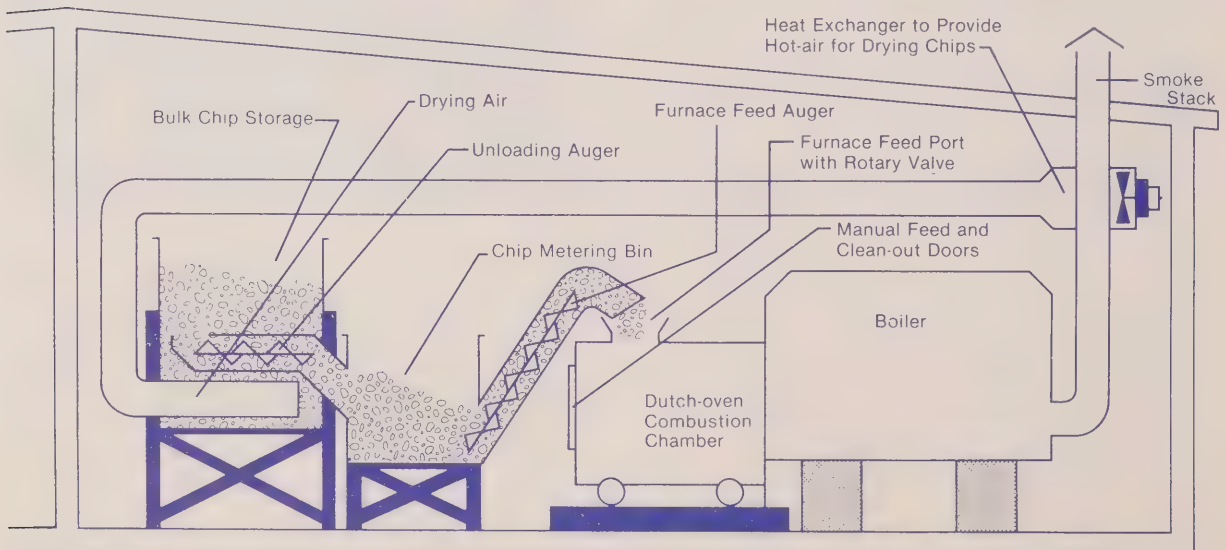
- Installation of a screen to remove over-sized chips;
- Removal of the rotary valve at the top of the Dutch Oven, which tended to jam.

Technical Details:

The Brookdale Nurseries greenhouse complex consists of 17 conventional greenhouses covering 0.75 hectares (1.85 acres), a retail display area of 370 m² (4,000 ft²), a farmers' market of 186 m² (2,000 ft²), a tropical plant display area, heated office, packing room, stock rooms, maintenance shop and connecting corridors. The complex is heated by a low pressure steam system operating at 40 kPa (6 psig), which is supplied by four 250 hp boilers and one 60 hp boiler, all formerly fired by fuel oil.

In late 1981, one of the 250 hp boilers, built by Dominion Bridge (model 250-06-3), was converted from fuel oil to wood chips by completely removing the original oil burner and attaching a custom-made Dutch Oven type combustion chamber. Connection to the boiler is made by means of a refractory-lined collar carried in a steel housing welded to the boiler front. The Dutch Oven is made of structural steel sections and steel plate welded into a box-like structure

2.4 m (8 ft) long by 1.8 m (5.75 ft) high by 1.7 m (5.5 ft) wide. The frame is mounted on wheels which run on steel tracks so that the Dutch Oven can be rolled back to enable boiler cleaning. The combustion chamber walls are lined with insulating firebrick and the arched ceiling is lined with cast-in-place refractory material. Combustion takes place on a horizontal cast iron grate 0.9 m (3ft) by 1.8 m (6 ft) located 0.3 m (1 ft) from the bottom. Combustion air is preheated in a plenum over the combustion unit — thus recovering heat which would otherwise be lost — and is delivered to primary air ports below the grate and secondary air ports 0.5 m (1.5 ft) above the grate. Ash is collected below the grate and scraped out periodically through hatches at the front and sides of the oven. Fly ash collects in the fire-tubes of the boiler to the point of constriction and is then removed by allowing the fire to burn out, rolling the oven away from the boiler and cleaning the tubes manually with a tube brush.



Hardwood and softwood are supplied by local cutters, are chipped on site using a Bruks chipper and stored in a shed. The chips are then moved by a farm tractor with a loading bucket and are dumped through a 15 cm (6 in) screen into an agricultural forage blower. The blower delivers the chips to a stationary forage wagon equipped with a scraper chain live bottom driven by a 20 hp electric motor. (See schematic diagram.) The transverse screw conveyor of the forage

wagon then loads the chips into a metering bin, from which the chips are fed, upon demand, into the Dutch Oven via an inclined screw conveyor and finally a rotary valve. The conveyor is controlled automatically by steam pressure changes in the boilers.

Finally, heat recovered from the boiler stack is used to provide partial drying of the chips in the bulk storage bin.

Economic Analysis:

Project Capital Costs

• Equipment	\$76,283
• Installation	<u>\$10,473</u>
Total:	\$86,756

Operation and Maintenance Costs

(for 83/84 heating season)

• Value of displaced oil 216,000 L @ \$0.22/L		\$47,520
• Cost of wood fuel 420 tonnes @ \$40/tonne	\$16,800	
• Cost of electricity for feed system 24,224 kWh @ \$0.05/kWh	<u>\$ 1,211</u>	
	\$18,011	(\$18,011)

Net Annual Savings: **\$29,509**

Simple Payback Period: 3 years.

Notes:

The delivered value of wood chips at \$40/tonne (\$44/ton) is based on the cost of wood at \$22-\$23/tonne (\$24-\$25/ton), plus chipping at \$7-\$8/tonne (\$8-\$9/ton) plus amortization of equipment at \$9-\$11/tonne (\$10-\$12/ton). The electrical costs include electricity for the fuel feed auger, forced and induced draft fans, feedwater pump, rotary air valve and all boiler controls but not for the motor for the live bottom day bin. This is approximately balanced by the inclusion of the feedwater pump and the saving on the retired oil burner.

Availability:

Mr. Lloyd Brown, the owner of Brookdale Nurseries, is a licensed stationary engineer as well as a plumber and electrician. These skills allowed him to design and build much of the system himself, partly by adapting farm machinery obtained from his farm equipment business. It is recommended that an experienced consulting engineer be used by those without such capabilities.

The steel fabrication was undertaken by York Steel of Fredericton, New Brunswick, and the refractory material was supplied by A.P. Green Refractories of Moncton.

Further information:

Further information on this system and a copy of the final technical report are available from:

- ENEROPTIONS
Energy Secretariat
Government of New Brunswick
P.O. Box 6000
Fredericton, New Brunswick
E3B 5H1
(506) 453-3897

The project manager and system owner is:

- Lloyd Brown
(re: ENEROPTIONS)
Brookdale Nurseries Ltd.
P.O. Box 422
Newcastle, New Brunswick
E1V 3M5
(506) 622-3424

Modifications to Wood-Chip Boiler



MARITIME FOREST RANGER SCHOOL

Technology:

Automatic wood-chip heating system

Annual Savings: \$22,750

65% reduction in wood fuel costs

Demonstration Project Manager:

Mr. George Walsh
Maritime Forest Ranger School
R.R. #5
Fredericton, New Brunswick
E3B 4X6

Payback Period: 1.4 years

Applicable to:

Institutional and commercial facilities located near forest processing industries.

Location:

Fredericton, New Brunswick

Description:

The existing wood-chip boiler system at the Maritime Forest Ranger School was modified and updated to improve efficiency, reliability and safety and to expand the range of cull wood it could use. The School, located in Fredericton, New Brunswick, has utilized wood as its primary heating source since its construction in 1946. Fuel wood is harvested in conjunction with the forest management of the University of New Brunswick's woodlots.

The original system fired 1.2 m (4 ft) roundwood logs, but was awkward and labour-intensive. The present wood-chip heating system was installed in 1978. Operating experience gained from 1978 to 1980 indicated that modifications to the heating system would further improve the functional reliability and safety of the plant. It also became apparent that the installation of a chip screen would expand the range of usable cull wood and thereby reduce fuel costs. These changes were made in 1981/82.



Benefits:

The modifications to the wood-chip heating system have:

- expanded the range of cull wood to include low grade roundwood and mill slabs, resulting in a 65% or \$22,750 annual saving in wood costs;
- reduced the total fuel cost per degree day by about 7%

(with wood prices held constant and stand-by oil prices rising);

- significantly improved system reliability;
- reduced dependency on the oil-fired stand-by system;
- reduced fly ash emissions.

Performance:

Each of the system modifications carried out under this demonstration have contributed to a significant increase in the overall reliability of the system. Improvements to the chip storage system have reduced chip bridging problems and the addition of the chip screen has allowed the chip handling system to operate for up to 2 months without blockage. This has virtually eliminated unscheduled interruptions.

Technical Details:

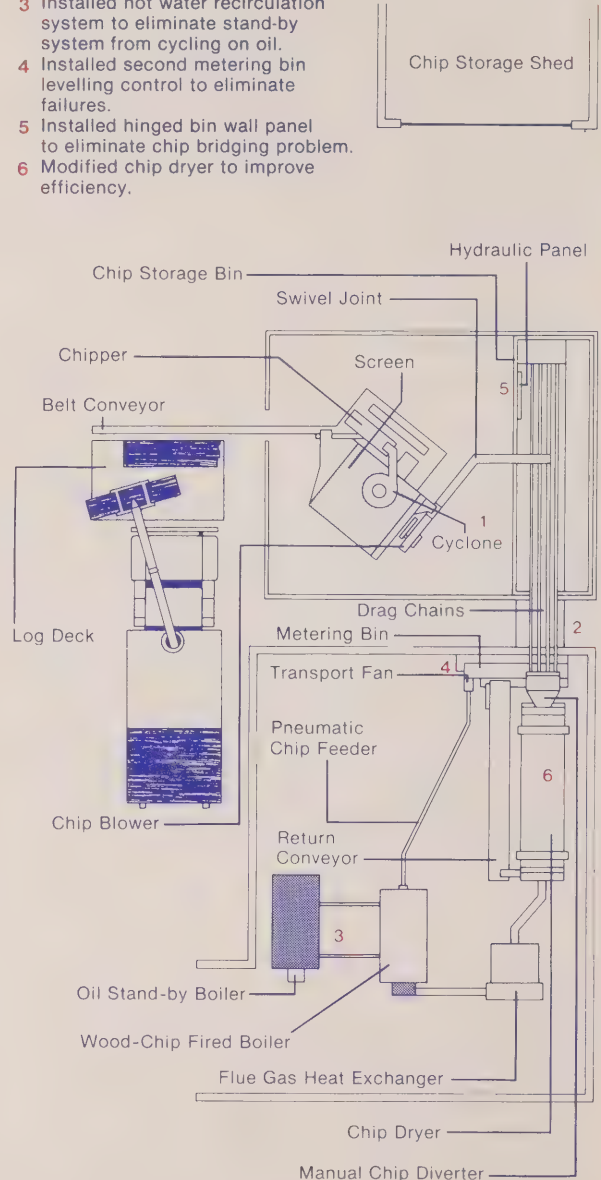
The schematic diagram of the wood-chip heating plant shows the six major modifications carried out within this demonstration. A brief description of each modification is presented below:

- **Chip screen and blower** — To eliminate feed system blockages resulting from cull wood splinters, a 1.8 m (6 ft) square oscillating chip screen was installed between the chipping and the storage bin. The cull wood is now fed through the chipper and exits into a cyclone located above the screen. The "accepts" are directed through a chute to a storage bin or to outside storage. The "rejects" are recycled through the chipper.
- **Drag chains** — Several flights of the storage bin drag chains were replaced to ensure continuous discharge. In addition, spacers and collars were added between each rear sprocket to prevent lateral movement and to eliminate previous misalignment problems. Finally, two chain rollers were added to support the return chain in order to reduce adjustments to chain tension.
- **Hot water recirculation** — A condensate recirculation system was installed to maintain the oil-fired stand-by boiler at operating temperature by using hot water from the wood-fired boiler.
- **Second metering control** — A second diaphragm type, high-level switch was added to the chip storage bin for positive level control during periods when the chip dryer was in operation.
- **Hinged bin wall** — A hydraulically actuated panel on the bin wall, hinged at the top and swinging outward at the bottom, was installed to counteract previous chip bridging problems which occurred towards the rear of the bin.
- **Chip dryer** — A cylindrical insert was installed in the centre of the existing dryer to increase the area of chips in contact with the warm air from the stack gas heat exchanger. The insert is hollow and has 6 longitudinal fins equi-spaced about the circumference. It also has a series of holes between two adjacent fins which allow chips to enter the centre portion of the insert. The insert is attached to the outer dryer shell and rotates concentrically with the dryer.

In addition to the above major modifications, combustion air was reduced, draft gauges were installed, a new safety switch (operating on the principle of differential pressure) was installed for operation of the induced draft fan on the stack, and the chip feed hopper was modified slightly.

The addition of the chip screen has also successfully broadened the range of usable cull wood. This means that the school's annual requirement of 700 cords of wood can now be supplied from a 50/50 mix of sawmill slabs @ \$10/cord and low-grade cull roundwood @ \$25/cord, instead of top-grade cull wood @ \$50/cord. This represents an annual wood fuel savings of \$22,750.

- 1 Installed chip screen and blower to eliminate chip feeding problems.
- 2 Modified drag chains to improve effectiveness.
- 3 Installed hot water recirculation system to eliminate stand-by system from cycling on oil.
- 4 Installed second metering bin levelling control to eliminate failures.
- 5 Installed hinged bin wall panel to eliminate chip bridging problem.
- 6 Modified chip dryer to improve efficiency.



Economic Analysis:

The modifications outlined above have collectively contributed to reduced fuel and maintenance costs as well as improved combustion efficiency. With the exception of the addition of the chip screen, the individual contributions of each modification have not been isolated. In the following economic analysis, the cost reductions resulting from the addition of the chip screen are assessed against the total project costs. If assessed against only the \$15,607 cost of the chip screen, the simple payback period is about 8 months.

Project Costs

• Chip screen	\$15,607
• All other modifications	\$16,134
Total Equipment and Installation:	\$31,741

Annual Wood Fuel Saving

• Previous cost		
700 cords		
top grade wood @ \$50		\$35,000
• New cost		
350 cords cull		
roundwood @ \$25	\$ 8,750	
350 cords slabs @ \$10	3,500	
Total:	\$12,250	\$12,250

Annual Savings:

\$22,750

Simple Payback Period: 1.4 years.

Availability:

The design, installation and monitoring of the system modifications were carried out by ADI Ltd., a New Brunswick engineering consulting firm specializing in wood burning systems. Similar services may be available in other locations across Canada.

Further Information:

A final report on this demonstration is available from:

- ENEROPTIONS
Energy Secretariat
Government of New Brunswick
P.O. Box 6000
Fredericton, New Brunswick
E3B 5H1
(506) 453-3897

Further information is also available from:

- Mr. George Walsh
(re: ENEROPTIONS)
Maritime Forest Ranger School
R.R. #5
Fredericton, New Brunswick
E3B 4X6
(506) 454-4363
-

Wood-Chip Heating

NEWFOUNDLAND HARDWOODS LTD. — CLARENVILLE, NEWFOUNDLAND

Technology:

A medium-scale wood burning heating system

Demonstration Project Manager:

Maurice Mills
Acres International Ltd.
44 Torbay Road
St. John's, Newfoundland
A1A 2G4

Location:

Clarenville, Newfoundland

Annual Savings: \$118,800
32% of previous fuel costs

Payback Period: 4.9 years

Applicable to:

- Manufacturing plants
- Institutions

Description:

Newfoundland Hardwoods Ltd. displaces approximately 1.36 million L (300,000 gals) of Bunker C oil annually and replaces it with 7,200 tonnes (7,900 tons) of green wood chips for a saving of \$118,800 annually. The company installed a new 300 hp Northfab wood-burning system to replace its oil-burning system to produce steam for its asphalt and creosote plant. Wood chips from mill waste and whole tree chips are supplied locally, which has created local employment. A local engineering consultant provided project management and assisted with integration of the purchased system into the existing plant.



Wood-fired boiler in position and ready for building enclosure.

Benefits:

- 1.36 million L (300,000 gals) of Bunker C oil were displaced by 7,200 green tonnes (7,900 tons) of chips for a saving of \$118,800 annually;
- Seven permanent jobs in the wood fuel supply business were created;
- Sulphur emissions have been reduced substantially as wood chips contain almost no sulphur;
- Reduced fire hazard and easier reforestation on land harvested for wood chips.

Performance:

The demonstration proved the technical and economic feasibility of a medium-scale wood burning heating system. No problems were experienced in installation, start-up or operations.

- The system has performed above expectations with the Northfab boiler providing all of the required steam.

- The wood-fired system takes one-sixth the time to reach top capacity from a cold start as did the oil-fired boiler.
- A reliable source of wood chips will supply fuel at \$33.50/green tonne (\$30.39/ton) for a period of three years.

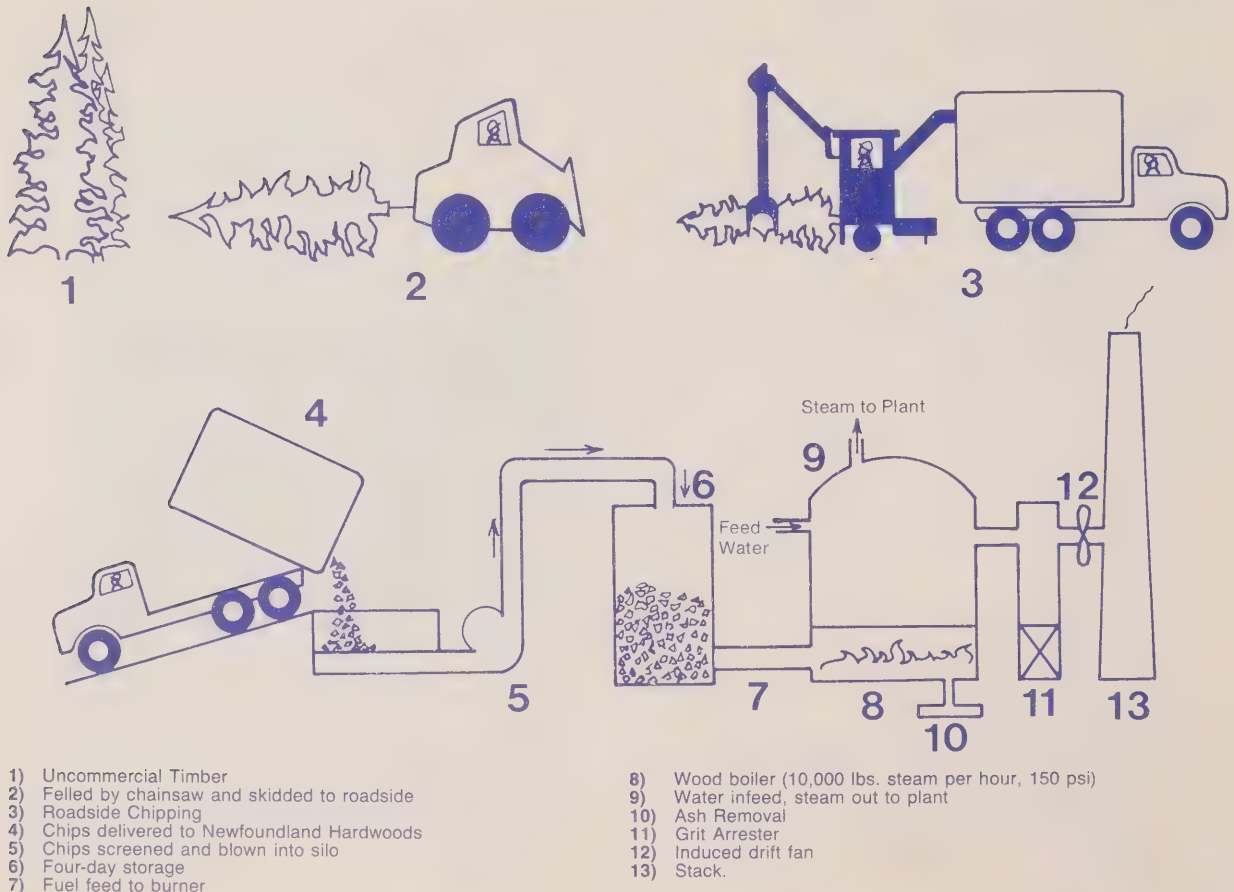
Technical Details:

The asphalt and creosote plant requires approximately 4,536 kg (10,000 lbs) of steam per hour at 1,034 kPa (150 psi) for the heating of asphalt tanks and the pressure treatment of timber. To meet these requirements, a 300 hp Northfab wood-fired boiler system was installed. The boiler system consists of a 4.9 m × 3.7 m (16 ft × 12 ft) boiler, a grit collector (with a 20 hp fan, grit bin, platform and accessories), an 11 m (35 ft) chimney and a stoker (screw type with a 2 hp motor, a 2 hp F.D. fan, and a 2 hp fuel metering screw).

The related material handling system has the following features:

- Silo 6 m × 6 m × 7.6 m (20 ft × 20 ft × 25 ft)

- Metal dumping bin
- Support frame and grating
- Live bottom for bin, 3 push-rods
- Unloading auger 46 cm (18 in)
- 6 m (20 ft) paddle conveyor to screen
- chip screen
- Incline conveyor to silo
- Electric starters for equipment and enclosure and control



Material flow diagram for Newfoundland Hardwoods, Clarenville

Economic Analysis:

Capital Cost: \$587,500

Payback Period: 4.9 years.

Operating Cost:

Bunker C oil

1,363,800 L @ \$0.264/L \$360,000

Replaced with wood chips

7,200 tonnes @ \$33.50/green tonne (\$241,200)

Net Fuel Savings:

\$118,800

Availability:

The boiler system was provided by:

- Northfab Systems
P.O. Box 202
Stratford, Ontario
N5A 6T1
(519) 271-5530

The engineering consultants were:

- Acres Consulting Services Limited
St. John's, Newfoundland

Similar technology is available from other sources across Canada.

Further Information:

For further information and a copy of the final report, contact:

- ENEROPTIONS
Energy Branch
Department of Mines and Energy
Government of Newfoundland and Labrador
P.O. Box 4750
St. John's, Newfoundland
A1C 5T7
(709) 576-2411
 - Maurice Mills
(re: ENEROPTIONS)
Acres International Ltd.
44 Torbay Road
St. John's, Newfoundland
A1A 2G4
(709) 754-1710
-

Energy from Wood Waste

FOOTHILL GREENHOUSE LTD. — KETTLEBY, ONTARIO

Technology

- Wood waste (biomass) used in small-scale direct combustion
- Small computer control of greenhouse environment

Annual Savings: \$46,580
61% of pre-demonstration fuel costs

Payback Period: 4.4 years

Demonstration Project Manager:

Foothill Greenhouse Ltd.
R.R. #1
Kettleby, Ontario

Applicable to:

- Greenhouses
- Nurseries

Location:

Kettleby, Ontario

Description:

A greenhouse in Kettleby, Ontario burns wood chips and sawdust instead of oil, resulting in energy savings of \$46,580 annually.

A small microcomputer controls and monitors heating,

ventilation and humidity in the greenhouse — less manpower is needed.

The local availability of abundant supplies of low-cost wood waste make this project economically attractive.

Benefits:

- Overall operating costs, based on burning wood wastes at \$30.40/tonne (\$27.64/ton) are 39% of those associated with burning bunker "C" oil at \$0.178/litre (\$0.80/gallon).
- The savings are \$46,580 every year, with 428,000 litres of oil displaced annually.
- The computer control of the greenhouse environment improved productivity by providing greater reliability and accuracy with less labour.
- The wood-burning system can effectively utilize lower grade, high moisture content (25%-40%) wood wastes, readily available at a low cost.

Performance:

- A Mottpac boiler was selected because of proven performance records from six other users of the same system. The installation of the boiler proceeded as expected, and the operation and maintenance program progressed without difficulties. The response time of the entire heating system adjusts rapidly to changes in heat demand.
- The boiler tubes remain reasonably clean and there was no sign of creosote build-up during the monitoring period. Cleaning of the system and removal of the ashes does not pose any problems. This is performed once every two months.
- For automatic operation, the feed silo has to be kept full and feed problems are encountered occasionally. The wood handling/feed system requires considerably more attention than an oil burner.

Technical Details:

Foothill's greenhouse covers an area of 6,040 m² (65,000 ft²). The company grows an exclusive crop of seedless cucumbers, which require a constant temperature of 21°C (70°F). This heat requirement makes fuel the most expensive item for cucumber production. An alternative heat source was needed and, in March 1982, it was decided to use wood waste as a fuel, since it was inexpensive and abundant.

The engineering consultants, Jellicoe Resource Associates Ltd., were engaged to conduct a feasibility study and provide a conceptual design for the demonstration project. Construction and installation were undertaken by the owner of the greenhouses. The monitoring period was September 1982 to December 1982. Prior to monitoring, the system was tested and the material handling system was improved.

Wood waste, for immediate use, is stored in a steel silo with a capacity of 54-64 tonnes (60-70 tons). Wood chips are blown by a 30 kW (40 hp) fan into the silo. The air used is piped back to the fan, thus controlling dust levels.

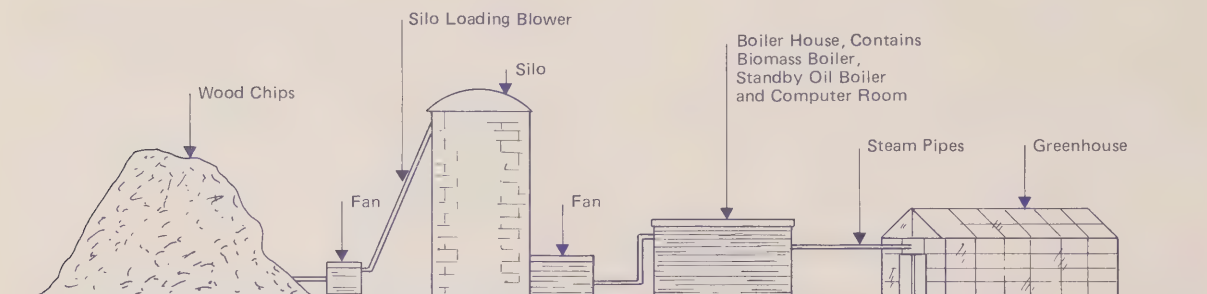
The fuel flows by gravity from the silo into a metering container. Then it is transported via a variable speed 15 cm (6 in) auger into the centre of a 7.5 kW (10 hp), 81 cm (32 in)

heavy duty fan. The fan blows the material, through a 10 cm (4 in) steel pipe, into the top of the boiler. The feed rate is variable from 180 to 1,000 kg/hr (400 to 2,200 lbs/hr).

The heating system is a 3-pass, suspension burning Mott-pac boiler with a 2,305 kWh (7.9 × 10⁶ Btu/hr) rating. The fuel enters the combustion chamber in a swirling pattern, while an 11 kW (15 hp) fan draws in primary combustion air from below the chamber. The high efficiency of the boiler is attributable to a multi-cyclone grit-arrester. It is designed to trap unburned particles and blow them back into the combustion chamber by way of a venturi system.

Steam is distributed to five climate controlled zones in the greenhouse by means of motorized steam valves. A micro-processor regulates the temperature in each zone by controlling these valves. Motorized vents and exhaust fans are also controlled by the microprocessor. The original boiler was retained as a backup source of heat. The standby heavy fuel oil is kept at 88°C (190°F) by the heat from the wood burner.

The response time of the entire heating system is good, and the boiler is able to adjust rapidly to changes made in the heat demand. This factor is of prime importance to the maintenance of crop production.



Biomass Storage and Boiler House Layout, Foothill Greenhouse Ltd.

Economic Analysis:

Capital Cost:

Item	Cost
Boiler	\$103,000
Silo	43,000
Filler system	14,000
Stack	3,500
Microprocessor	26,500
Insulation	4,000
Electrical	6,000
Miscellaneous	3,000
Total Capital Cost*	\$203,000

*(Expenditures for construction and installation labour are not included as the owner did the work himself.)

Operating Cost Comparison (Wood at about 10% moisture content):

- 1 tonne (1.1 tons) of wood waste was found to supply the same heat output as 475 litres (104.5 gallons) of bunker "C" oil.
- Approximately 909 tonnes (1,000 tons) of wood waste is required annually.
- Wood waste costs \$30.40/tonne (\$27.64/ton) while oil costs \$0.178/litre (\$0.80/gallon).
- Annual operating cost comparison:

Item	Wood System	Oil System
Fuel	\$27,640	\$76,000
Electricity	1,020	240
Labour	1,000	—
Total	\$29,660	\$76,240

- Annual savings: \$46,580

Simple Payback Period: 4.4 Years.

Availability:

The technology and suppliers of equipment are available throughout Canada in major centres. Experienced consultants should be retained to conduct feasibility and design

studies. The local availability of a wood waste supply at a reasonable price is a key factor in determining the attractiveness of this approach.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
Conservation and Renewable Energy Office
Energy, Mines and Resources Canada
Room 606, P.O. Box 2009
55 St. Clair Ave. East
Toronto, Ontario
M4T 1M2
(416) 973-1608 or
1-800-387-0733 (toll free in Ontario)

Information on the demonstration project is also available from the consultant:

- Biomass Thermal Utilities Inc.
(re: ENEROPTIONS)
1665 Kipling Ave.
Weston, Ontario
M9R 2Y4
(416) 242-5166
-

CA
MS 220
- ES

Wood Heating of Fort Smith Water Supply

Technology:

Large-scale, direct combustion of wood chips

Annual Savings: \$44,471

100% of fuel oil previously used

Demonstration Project Manager:

Jack Dueck
Apsco Engineering Ltd.
P.O. Box 270
Cremona, Alberta
T0M 0R0

Payback Period: 4.6 years

Applicable to:

- a wide range of institutional, municipal and commercial space and water heating applications
- of particular interest to northern communities requiring heated water supply.

Location:

Fort Smith, N.W.T.

Description:

Fort Smith, N.W.T. is saving over \$44,000/year and creating local employment by heating its water supply with wood. Fort Smith, located approximately 300 km (185 miles) south of Yellowknife, must heat its water supply during much of the year. As in many communities in the Northwest Territories, the town's water supply was previously heated by conventional oil-fired boilers. However, escalating fuel oil prices dramatically increased the system's operating costs and prompted the search for a less expensive alternative.

The town's water supply is now heated by means of a 4.0 MBtu/hr Apsco Model WW1000 wood-fired hot water boiler unit. The boiler is fuelled by wood chips, processed on-site from locally purchased cordwood.



The wood-fired boiler is seen to the left and the wood-chip storage bunker is to the right. The inclined auger is seen in the foreground.

Benefits:

- In its first year of operation, the project resulted in the displacement of approximately 160,000 litres (35,195 gallons) of No. 2 fuel oil.
- Once start-up problems, related to chip bridging in the storage bin, are overcome, it is expected that the project will result in the total displacement of approximately 200,000 litres (45,000 gals) of No. 2 fuel oil by approximately 400 cords of local wood.
- The new wood boiler has a larger capacity than the oil boilers. This enables the water supply to be maintained at a higher and more optimal temperature (4.4°C) for more effective water treatment than previously (2°C).
- Three permanent part-time jobs have been created in connection with the harvesting, delivery and chipping of local cordwood. Funds spent on fuel now stay in the community.

Performance:

The design and installation of the system proceeded as expected and no problems were encountered. The boiler has performed at, or above, expectations since installation. A minor start-up problem was encountered with the wood chipper but was quickly identified and eventually remedied. There has been a continuing problem, however, with the wood-chip handling system. Each problem is outlined below.

- Wood chipper — The attachment blades originally provided by the supplier were shorter than those specified by the design engineer. As a result, the chips were not being adequately thrown from the chipper unit to the

conveyor belt. The problem was quickly identified and proper replacement blades were provided by the supplier. However, due to the inexperience of the on-site personnel, the replacement blades were not installed for several months. Once the replacement blades were installed, the chipper unit performed well.

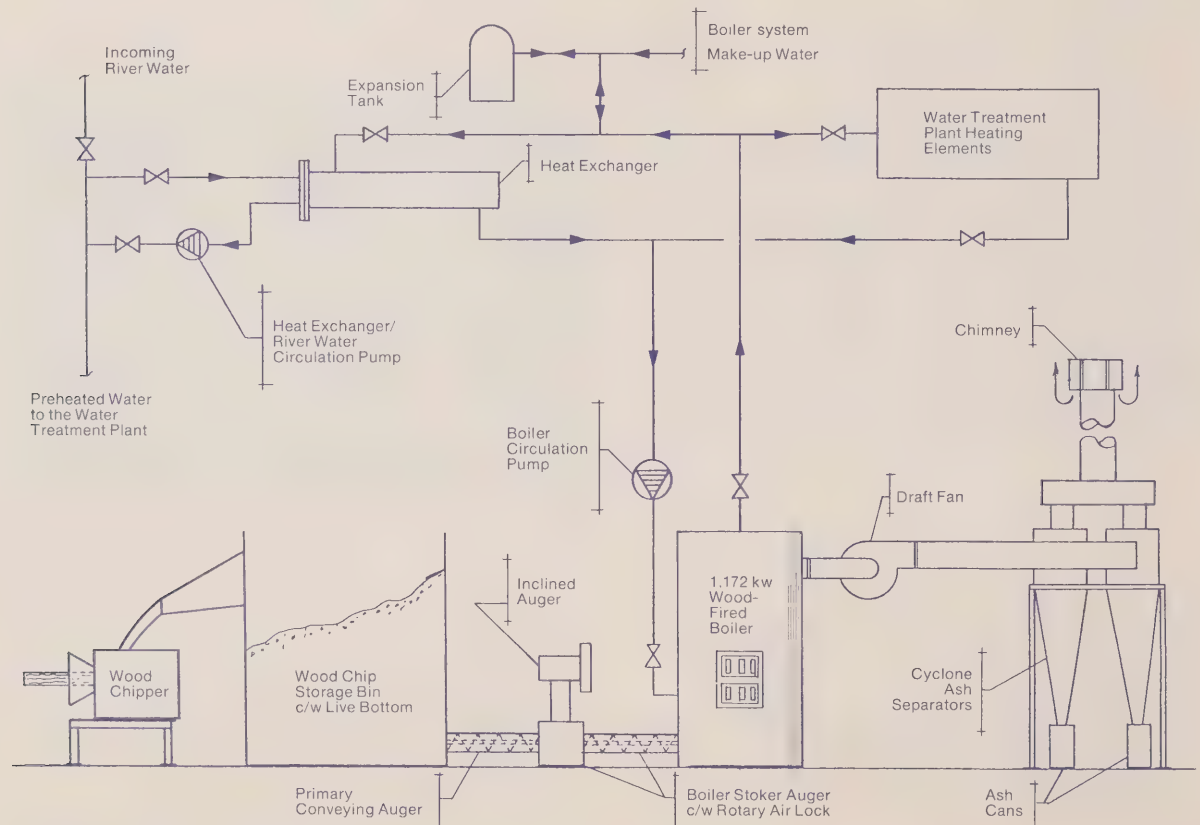
- **Wood-chip handling system** — A continuing chip bridging problem exists with the hydraulic live bottom in the storage bin. This problem has lowered the system's availability to about 80% and is currently under investigation but is felt to be correctable.

Technical Details:

The schematic diagram shows the new wood boiler system. All facilities, including the chipper and storage bunker, are located indoors in an insulated steel building.

Wood fuel is chipped to allow automatic feeding of the boiler. The wood-chip storage bin has a live bottom which allows the primary auger at the base of the storage bin to meter the flow as required. The primary auger has a variable speed drive enabling the boiler feed rate to be adjusted according to heating requirements and/or fuel moisture content. A rotary air lock provides a separation between fuel and the firebox.

The Apsco Model wood-fired boiler is a three-pass, vertical fire tube boiler with a design thermal efficiency of 75%. The design allows the hot gases from the firebox to travel vertically through the boiler in three passes before exiting. Primary combustion air is provided from beneath the boiler. The gases produced during primary combustion are burned above the wood chips when mixed with secondary air. Both the fuel feeding rate and the air supply are adjusted to achieve an efficient fuel/air mixture under various operating conditions.



Wood Boiler Heating System Schematic

The boiler is supplied with a complete set of controls to maintain a preset boiler supply water temperature. The water side of the boiler supplies two separate loops. The primary loop feeds the new heat exchanger which heats part of the incoming river water before it enters the water treatment plant. The portion of the river water (at .5° C) that passes through the heat exchanger has its temperature raised to a point that, when mixed with the remaining portion, results in a water temperature of approximately 4.4° C (40° F).

The second loop from the boiler heats the water treatment plant. The existing oil-fired boilers now serve as backup.

As a result of the extremely high boiler hearth temperatures, almost all of the hydrocarbons are consumed and only fly ash remains. The fly ash is separated from the exhaust emissions with high efficiency cyclones.

Economic Analysis:

Capital and Installation Costs: \$206,874

Simple Payback Period: 4.6 years.

Avoided Cost of Fuel Oil

(195,138 L @ \$0.353): \$ 68,835

Annual Operating Cost for Wood Boiler

• Cost of wood supply:	
- Harvesting and delivery (392 cords @ \$37.50)	\$14,700
- Labour for wood chipping (336 hrs @ \$8)	\$ 2,688 (1)
• Incremental maintenance cost:	\$ 469 (1)
• Incremental electricity cost:	\$ 6,507 (2)
Total	\$24,364 (3) (\$ 24,364)
Net Annual Savings	\$ 44,471

Notes:

1. Incremental labour costs for wood chipping and regular maintenance are site-specific and are dependent on current labour loading. In many locations, these tasks may be handled by existing staff
2. Incremental electricity costs are primarily for operation of the electric chipper; in Fort Smith the levy of an energy demand charge of \$4,771 makes the operation of an electric chipper far more expensive than the comparable operating cost of a gas-powered chipper. Additional annual operating cost savings of approximately \$4,000 are possible through the use of a gas-powered chipper.
3. In those locations where a gas-powered chipper is used and existing staff are able to perform wood chipping and regular maintenance duties, annual operating costs for a comparable wood system may be as low as \$21,000. This would result in a simple payback of 4.3 years.

Availability:

The system was designed and installed by Apsco Engineering Ltd. of Cremona, Alberta.

The technology is available through contractors, suppliers and engineering consultants in major centres throughout Canada.

Further Information:

Further information and a copy of the final report are available from:

- ENEROPTIONS
Energy Conservation Division
Department of Public Works and Highways
Government of the Northwest Territories
Yellowknife, N.W.T.
X1A 2L9
(403) 873-7202

Information on this demonstration project is also available from the consultant:

- Mr. Jack Dueck
(re: ENEROPTIONS)
Apsco Engineering Ltd.
P.O. Box 270
Cremona, Alberta
T0M 0R0
(403) 286-2199

Wood Residue Fuelled Boiler

UNIVERSITY OF NEW BRUNSWICK

Technology:

Large-scale, direct combustion of wood residues

Demonstration Project Manager:

John Dean
Northeast Energy Services Ltd.
1115 Regent Street
Box 44, Station A
Fredericton, New Brunswick
E3B 4Y2

Location:

University of New Brunswick, Fredericton

Annual Operating Savings: \$820,000

72% of previous oil consumption

Payback Period: 3 years

Applicable to:

- Universities
- Schools
- Municipalities
- Large industry
- Hospitals
- Remote communities in areas where there is a secure supply of wood residue

Description:

The University of New Brunswick has returned to a New Brunswick tradition of wood heating for its Fredericton campus — but with a high-tech twist. The University's district heating wood-fired boiler, the largest east of Montreal, provides space heating and domestic hot water for the entire university, two large apartment buildings, and the 485-bed Dr. Everett Chalmers Hospital. Since installation in 1970, the system has been serviced by two oil-fired boilers.

Under this project an 18,000 kg/hr (40,000 lbs/hr) wood-residue fired boiler was installed in the heating plant. It was designed to operate in a base-load mode in tandem with the oil-fired boilers and to displace 7 million L (1.5 million gals) of Bunker C oil annually. In addition, wood fuel storage silos and handling/feeding equipment were installed. The fuel is wood residues consisting of bark, sawdust, chips, shavings and harvesting waste. Apart from the large size of the facility, there are two other unique elements:

- The project was undertaken on an innovative turnkey basis, including savings financing through a 9-year contract between UNB and Northeast Energy Services Ltd.
- The wood fuel is supplied under a 9-year guaranteed contract and draws on residue from several wood processing plants within 60 km (37 miles) of Fredericton.



The wood residue fuelled boiler is installed in the central heating plant.

Benefits:

Based on a 12 month monitoring period ending April 30, 1985, the following benefits were realized:

- A 72% contribution by the wood-fired boiler to the total load. This is higher than the projected contribution of 69% of annual requirements.
- The operating savings over this period were \$820,000 based on displacing 7.05 million L (1.55 million gals) of oil worth \$1,800,000.

Performance:

Overall during the monitoring period, the wood-fired boiler operated at or above expectations. The most significant results were:

- The boiler produced 107 million kg (235.4 million lbs) of steam, equivalent to 72% of the plant's total output.
- The amount of oil displaced was worth \$1,800,000 in gross savings. Once the cost of wood fuel and incremental operating and maintenance costs (at an estimated total of \$980,000) are taken into account, the net savings are \$820,000. This is equivalent to a \$7.74 saving per 1,000 kg (\$3.48 per 1,000 lbs) of steam produced.
- The average moisture content of the wood fuel was 50.4% and the average boiler efficiency (input-output basis) was 68.2%. Combustion efficiency and steam output per unit of fuel varied inversely with the moisture content of the fuel.
- Overall quality of the wood fuel was important to both boiler efficiency and reliable operation of the fuel handling system. The key quality factors were moisture content, wood sizing and blend. The most satisfactory blend was 30-40% bark and 60-70% sawdust and shavings.
- The environmental controls operated effectively, removing over 90% of particulate matter, and achieved particulate emissions 65% below the regulatory standard.
- The optimum furnace draft to balance thermal efficiency and emissions was achieved by adjusting for 3% excess oxygen and 40% opacity.

Technical Details:

The original steam plant, built in 1970, has two boilers firing number 6 (Bunker C) oil with a combined rated capacity of 54,500 kg (120,000 lbs) of steam per hour at 1,723 kPa (250 psig). The annual steam production for the plant has varied from a low of 150 million kg (330 million lbs) of steam to a high of 159 million kg (350 million lbs). The corresponding annual oil consumption was between 10.0 million litres (2.2 million gals) and 11.4 million L (2.5 million gals). The winter load rarely exceeds 45,350 kg/hr (100,000 lbs/hr) and the summer load is seldom less than 6,800 kg/hr (15,000 lbs/hr). The load factor is relatively high as a result of the hospital demand, which includes both domestic hot water and air conditioning in the summer.

The wood-fired boiler, built by Babcock-Wilcox, has a capacity of 18,000 kg/hr of steam (40,000 lbs/hr) at 1,723 kPa (250 psig) when firing wood fuel with a moisture content of 50% (wet basis). It was designed to handle the entire summer load and up to 60% of the winter steam demand. Installation of the new boiler took 6 months and was completed in March 1984. It is connected in tandem with the existing oil-fired boilers.

- Acceptable emissions to the air in general and a reduction in SO₂ by burning wood in place of oil.
- A substantial demand for wood residues in the Fredericton area — the stimulus for creating a major wood residue infrastructure in central New Brunswick.
- Creation of nine person-years of new jobs in the heating plant and wood preparation facility.

Several relatively minor problems were encountered, particularly during the first 2 months of operation, and corrective actions were taken as follows:

- Wood fuel quality was low in the first few months. High moisture content caused silo clogging and reduced combustion efficiency. Oversized and stringy bark plus contamination with soil, rock and metal caused jamming in the wood transport system and excessive clinker build-up. These problems were overcome by installing a concrete pad for wood storage (thus reducing rock and sand carryover), a magnet to remove metal fragments, a disc screen and hogger to produce more uniform chips, reducing the amount of bark in the mixture to 30 to 40%, and making various adjustments to the woodfuel handling system.
- There was excessive clinker build-up in the boiler, necessitating shutdown and cleanout twice a day. This resulted from contaminants in the bark component of the fuel and lack of excess combustion air — both of which have been improved.
- Unexpected build-up of creosote on the dust collector tubes was improved by over-firing.
- Excessive friction and noise in the conveyor was corrected by the addition of Teflon wear strips.
- A complete boiler inspection, undertaken by Babcock-Wilcox, revealed only a minor loss of refractory around the inspection/cleanout door; this was repaired.

The wood fuel for the boiler is a mixture of bark, sawdust, chips, and shavings which is collected from four sawmills within a 60 km (37 mile) radius of Fredericton and then hogged and screened 2.5 km (1.5 miles) from the heating plant. The fuel is transported by large vans and dump trucks. Each load is weighed and a moisture content sample is taken. After dumping, the fuel is transported using a bottom scraper, screw conveyor, elevator buckets, and a chute to one of the two storage silos.

Each silo has a storage capacity of 136 tonnes (150 tons) of wood residue. Together they provide a storage capacity of two days at full load.

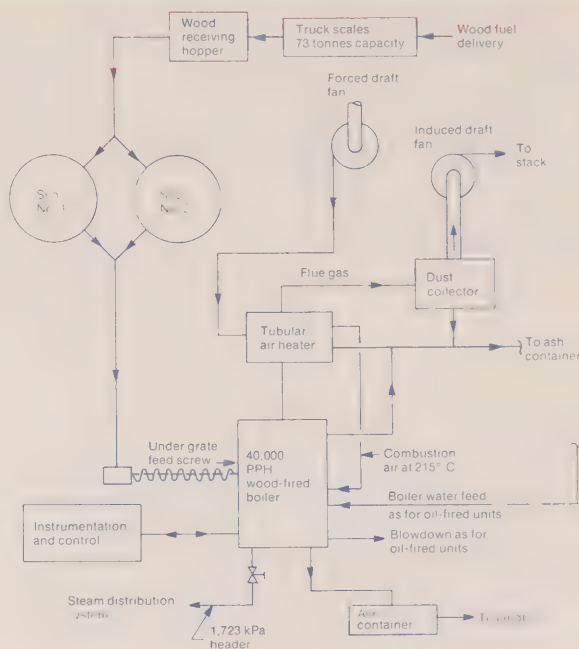
Wood fuel is discharged from the silos on demand using a chain flail-type agitator and is fed into a metering bin. From here it is transported via a variable speed screw (the feed rate of which is controlled by the load demand on the boiler) to a drag chain conveyor, which in turn feeds the boiler stoker screw. The entire wood fuel handling system can transport a maximum of 9 tonnes (10 tons) of fuel per hour to the burner.

The furnace itself is of the Towerpak Design with wood feed from an undergrate screw feeder with a centre discharge onto the pin hole grate. The combustion air is drawn from within the plant, preheated in a tubular heat exchanger to a temperature of 215° C (420° F) and directed into the combustion chamber in three different ways:

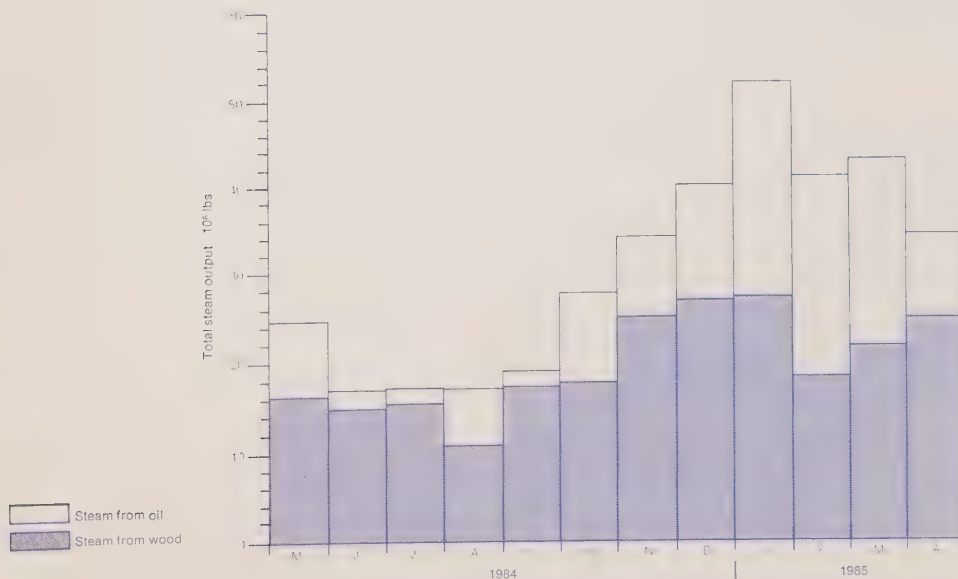
- Low pressure underfire air via pin hole grates to dry the fuel and provide primary combustion air;
- Low pressure overfire air via a peripheral plenum 0.6 m (2 ft) above the grate;
- High pressure overfire air from a high pressure fan via a duct 1.2 m (4 ft) above the grate to ensure complete combustion and minimize carry-over of unburnt wood to the exit gas.

The combustion gases leave the furnace area and pass through the generating bank, which transfers convective heat for steam generation. The gases exit the boiler at a temperature of 316° C (600° F). The fuel gas waste heat is recovered in a tubular air heater before entering the dust collector unit. The dust collector is a mechanical multi-cyclone collector manufactured by Air Correction, U.O.P. Inc. The centrifugal action of the gas passing through the collector tubes separates the solid particles, such as dust and ash, from the gas streams. The cleaner gases leaving the collector enter the inlet of the induced draft fan, which controls the furnace pressure automatically to the desired set point. The combustion gases are then directed into the existing plant stack for discharge to the environment.

Wood ash and fly ash are removed from four collection points (the furnace grate, generating bank hoppers, air heater hopper and the dust collector unit) and are transported by screw conveyors to enclosed bins which are emptied at the landfill site.



*Addition of wood-fired boiler
University of New Brunswick*



University of New Brunswick central heating plant. Steam production for first year of operation (by month).

Economic Analysis:

Project Capital Costs (including interest during construction):

Site works	\$ 420,500
Machinery & equipment	\$ 446,000
Wood boiler and auxiliaries	\$1,384,000
Instrumentation and controls	\$ 118,000
Piping and valving	\$ 9,500
Electrical work	\$ 42,000
	<hr/>
	\$2,420,000

Annual Operating and Maintenance Costs (preliminary)

• Value of displaced oil (7.05 million L)	\$1,800,000
• Cost of steam from wood plus extra operating and maintenance costs	(\$ 980,000)
Operating Savings:	<hr/>
	\$ 820,000

Simple Payback Period: 3 years.

Under the innovative financing scheme, the University retains a portion of the annual savings and provides the remainder to Northeast Energy Services to cover operating, maintenance, training, technical services and support, debt repayment, administration and profit over a 9-year period.

Availability:

- The entire system was custom designed and installed by Northeast Energy Services Limited with ADI Limited of Fredericton acting as consulting engineers.
- The boiler (the largest central heating wood boiler east of Montreal) was built to specifications by Babcock-Wilcox Canada Ltd.
- Northeast provided an intensive one-month training program for operating and maintenance staff as well as start-up supervision for the project.

- The long-term wood fuel supply contract was provided by Northeast as part of the "turnkey" development agreement.
- Technical and operating assistance is provided by Northeast Energy Services Ltd. for 9 years as part of the "turnkey" arrangement.

Similar design and build services may be available across Canada. Experience with large wood-fired systems will be an important element in selecting a contractor.

Further Information:

Further information on the system and a copy of the final technical report are available from:

- ENEROPTIONS
Energy Secretariat
Government of New Brunswick
P.O. Box 6000
Fredericton, New Brunswick
E3B 5H1
(506) 453-3897

Further information is also available from the demonstration project manager:

- Northeast Energy Services Ltd.
(re: ENEROPTIONS)
1115 Regent Street
P.O. Box 44, Station A
Fredericton, New Brunswick
E3B 4Y2
(506) 452-9011
-

Automatic Wood-Fired Boiler

GRENVILLE CHRISTIAN COLLEGE — BROCKVILLE, ONTARIO

Technology:

Automatic wood (biomass) burning system, using a direct combustion boiler

Demonstration Project Manager:

Grenville Christian College
P.O. Box 610
Brockville, Ontario

Location:

Brockville, Ontario

Annual Savings: \$75,000

68% of the pre-demonstration fuel costs

Payback Period: 4.4 years

Applicable to:

Facilities with space heating using hot water radiators, and where a secure supply of wood is available:

- Schools/Colleges
- Hospitals
- Remote communities

Description:

Ontario's first large, fully automated institutional wood heating system was started up in the fall of 1982 at Grenville Christian College in Brockville.

The system is designed to produce 5.7×10^6 L/hr (1.26×10^6 gals/hr) of hot water at a temperature of 110°C (230°F). The wood burning unit consists of an ignition cell, a combustion cell and a fire-tube hot water boiler.

The hot water generated by the boiler is pumped under a pressure of 172.4 kPa (25 psi) to the College to provide space heating through hot water radiators. In addition, hot water is circulated through a heat exchanger to provide hot tap water. The new system has sufficient capacity to meet anticipated growth of the College over the next 15 years.

Eventually, the College intends to supplement its purchased wood supply by producing wood chips from its own hybrid poplar plantation.



Benefits:

- An estimated average annual savings of \$71,000 in fuel costs can be realized at current prices. The actual savings during the monitored year were \$74,929 due to an increase in oil prices and a decrease in the cost of wood fuel.
- This fuel substitution demonstration showed that approxi-

mately 1,000 dry tonnes (1,100 dry tons) of wood chips can replace 345,000 litres (76,000 gals) of #2 Bunker fuel oil in an average year.

- Substitution of wood chips for a non-renewable fuel has proven feasible for the supply of all hot water to the College.

Performance:

- Downtime due to system failure was only 149 hours during the monitoring period. This amounted to an equipment availability of 98% which, considering the type of fuel used, indicates a high degree of reliability.
- Boiler efficiency was measured between 52% and 72% using heat loss method. The average wood burning efficiency was computed at 66%.
- Annual fuel savings, during the monitoring period, was 5.5% higher than predicted savings, largely due to increased oil prices in 1983.
- Boiler particulate emissions were within limits imposed by current regulations. SO₂ emissions were well below provincial impingement standards.
- The installation of refractory material in the combustion cell was below expectations. It should have been installed by a specialist. Consequently, major renovations were required before start-up.
- The facility performed as well as expected. During the monitoring period however the following problems were cited:
 - The induction fan system was engineered improperly and required redesigning and replacement.
 - Bridging and jamming in the augers was a constant problem due to the stringy nature of the wood fuel. The use of more costly high quality slab chips would eliminate this problem.
 - It is difficult to maintain good combustion during warm weather conditions due to low demand. Wet or dirty fuel creates problems during these periods and increases operator maintenance time.
- In general, during cold weather conditions the system operates with high efficiency and atmospheric emissions are lower. The efficiency drops off with lower load requirements so the system is shut down during the summer.

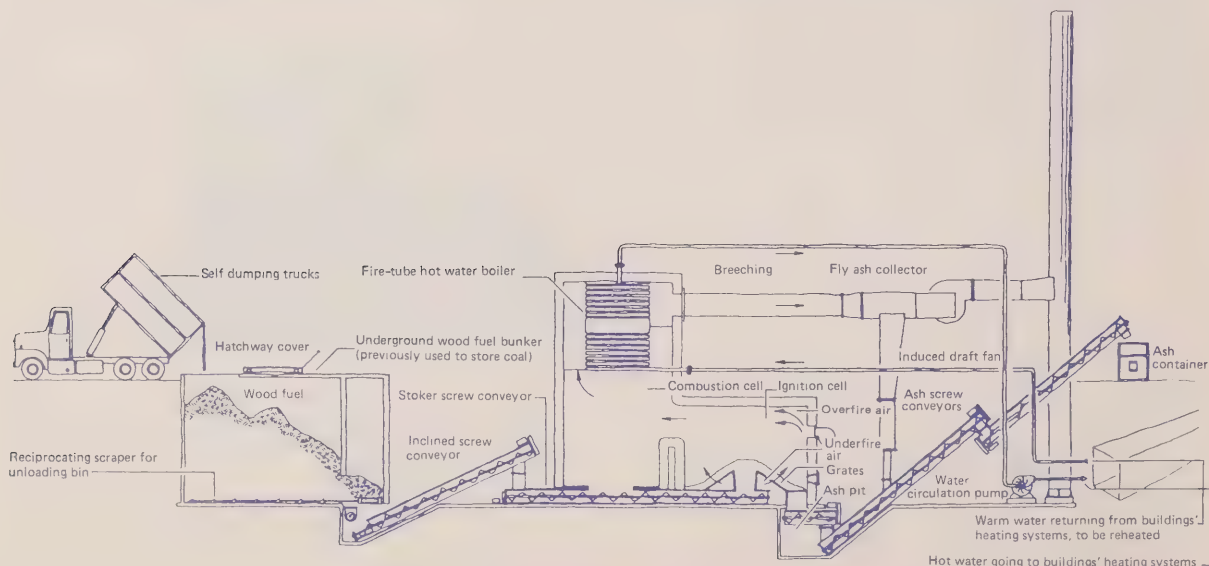
Technical Details:

- Grenville Christian College installed a large Anga-Varme 5.3 GJ/hr (5.0×10^6 Btu/hr) fully automated institutional wood heating system, as illustrated in the schematic diagram, in the fall of 1982 and closely monitored performance from November 1982 to December 1983.
- Stack emission testing was conducted at regular intervals by Envirocon Eastern Ltd.
- Wood fuel delivered to the College by independent contractors is weighed on arrival. The material must conform to specifications limiting particle size and moisture content. A sample is removed and analysed for moisture control and payment is based on its dry weight. The wood fuel is dumped into an underground storage bunker which holds one week's supply. This bunker is equipped with a reciprocating scraper to unload the bin. The fuel flows onto a system of inclined and horizontal screw conveyors to feed the furnace.

The wood burning unit consists of an ignition cell, a combustion cell and a fire-tube hot water boiler. A horizontal stoker screw conveyor moves the fuel into the ignition cell. On its way to the ignition cell the wood is exposed to the combustion cell where hot gases and radiation vaporize a considerable amount of its moisture content.

In the ignition cell the fuel is forced upward through an opening where it spreads over a number of sloping grates arranged in a circle. Air is injected under the grates to remove more moisture from the fuel, to assist fuel ignition and also to cool the grates. Air is also introduced above the grates by an overfire fan, mixing with the hot gases as they enter the combustion cell. The narrow passage at the entrance to the combustion cell causes the gases to accelerate.

The burning process is completed in the combustion cell. Here, the velocity of the gases decreases. This causes larger unburnt particles to drop into the stoker screw conveyor which returns them to the ignition cell along with fresh fuel.



The furnace reaches a temperature of 1,900° C (3,452° F).

Spent combustion gas is drawn through the boiler and breeching by an induced draft fan into a fly ash cyclone collector. Solid particles in the gas stream are removed and fall back onto an inclined ash screw conveyor. The cleaned gases are decelerated and pass out through the stack. Ash is removed manually every 3 to 4 days by raking out the ash pits provided on each side of the ignition cell. A system of screw conveyors automatically removes the ash from the ash pits to an ash disposal container outside the building. The 635 kg (1,400 lbs) of ash generated per week is used on school roads in the winter and in the garden as fertilizer in the summer.

The hot water generated by the boiler is pumped to the College buildings through pipes located in underground

tunnels. The College buildings are heated by this hot water passing through radiators. The cooled water circulates back to the boiler house and is pumped through the boiler for reheating. The hot water is also circulated through a heat exchanger to provide domestic hot water.

The temperature of the water leaving the boiler is monitored to automatically control boiler output. When the temperature of the outlet water falls to and below 86° C (187° F) the boiler goes into the high fire mode, and when the water rises to and above 92° C (198° F) it switches from high fire to low fire. The duration of operation of the induced draft fan, stoker screw conveyor and the overfire fan depends on timers associated with high fire or low fire operation. The boiler adjusts to different loads by varying the duration of each firing cycle.

Economic Analysis:

Actual energy costs were monitored during 1983. In order to estimate annual savings, an estimate of what 1983 costs would have been (using oil) was developed. This analysis is as follows:

Project Capital Cost

Wood burning system	\$177,938
Labour	149,305
Total Installed Cost	\$327,243

Annual Savings:

Equivalent 1983 oil cost	
— 341,745 litres @ \$0.321/litre	\$109,700
Actual 1983 Energy Costs	
— 665 oven dry tonnes wood @ \$37/tonne	24,605
— 29,660 litres of oil @ \$0.321/litre	9,521
— Electricity	645
Total 1983 Energy Costs	34,771
Annual Savings	\$ 74,929

Simple Payback Period: 4.4 Years.

If the system was used to its full capacity, payback could be as little as 1.5 years. The College was forced to an oversized unit, since none were available in the required size.

Availability:

- The unit was built in Canada according to a Swedish design, under the direction of Anga-Varme (Canada) Ltd. of Thunder Bay, Ontario. Other suppliers of wood burning systems may provide similar equipment.
- A reputable and qualified consulting engineer should be selected to supervise the general contractors. The supplier should maintain major servicing of the equipment after installation.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
Conservation and Renewable Energy Office
Energy, Mines and Resources Canada
Room 606, P.O. Box 2009
55 St. Clair Ave. East
Toronto, Ontario
M4T 1M2
(416) 973-1608 or
1-800-387-0733 (toll free in Ontario)

CAI
MS 230
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☐ Other (please specify)

8. Would you like to be on the **mailing list** for further information on new energy conservation and renewable energy technologies?

- ☐ Yes ☐ No

9. Respondent name and address: (optional)

Name: ~

Title:

Organization:

Address:

Postal Code:

Telephone No. ()

Date form completed:

Thank you for completing this Feedback Form. Please return it to:

ENERGOPTIONS FEEDBACK

Box 4517
Station "E"
Ottawa, Ontario
K1S 5B5

ENEROPTIONS materials are available for the following sectors or subject areas:

- INDUSTRIAL - *Broad Application*
- INDUSTRIAL - *Food Processing*
- INDUSTRIAL - *Forest Products*
- WOOD RESIDUE BURNING
- COMMERCIAL - *Broad Application*
- MUNICIPAL - *Broad Application*
- MUNICIPAL - *Recreational*
- INSTITUTIONAL - *Broad Application*
- INSTITUTIONAL - *Educational*
- RESIDENTIAL
- AGRICULTURAL - *Greenhouses*
- AGRICULTURAL - *Farming*
- REMOTE COMMUNITIES
- CONSULTING ENGINEERS
- ARCHITECTS
- UTILITIES

Copies of these materials are available from the offices listed overleaf.

ENEROPTIONS materials are available from:

National Office

ENEROPTIONS
Energy, Mines and Resources Canada
Box 4517
Station "E"
Ottawa, Ontario
K1S 5B5
(613) 995-9447

Newfoundland

- Energy Branch
Department of Mines and Energy
Government of Newfoundland and Labrador
95 Bonaventure Ave.
P.O. Box 4750
St. John's, Newfoundland
A1C 5T7
(709) 737-2411
- Energy, Mines and Resources Canada
Box 65, Atlantic Place
3rd floor, Suite 301
215 Water Street
St. John's Newfoundland
A1C 6C9
St. John's: (709) 772-5353
Elsewhere: Zenith 07792
(toll free in province)

Nova Scotia

- Energy, Mines and Resources Canada
Bank of Montreal Tower
5th Floor, Suite 503
5151 George Street
Halifax, Nova Scotia
B3J 1M5
Halifax: (902) 426-8600
Elsewhere: 1-426-8600
(toll free in province)

New Brunswick

- Energy Secretariat
Government of New Brunswick
124 Saint John St.
Box 6000
Fredericton, New Brunswick
E3B 5H1
(506) 453-3897
- Energy, Mines and Resources Canada
835 Champlain Street
Dieppe, New Brunswick
E1A 1P6
Moncton: (506) 857-6070
Elsewhere: 1-800-332-3908
(toll free in province)

Prince Edward Island

- Energy, Mines and Resources Canada
Brecken-Yates Bldg.
Harbourside #1
Charlottetown, P.E.I.
C1A 8R4
Charlottetown: (902) 566-7373
Elsewhere: 1-566-7373
(toll free in province)

Quebec

- Energy, Mines and Resources Canada
Guy Favreau Complex
200 Dorchester Blvd. West
West Tower, 5th Fl. Rm 501
Montreal, Quebec
H2Z 1X4
Montreal: (514) 283-5632
Elsewhere: 1-800-361-2671
(toll free in province)

Ontario

- Energy, Mines and Resources Canada
55 St. Clair Avenue East
Room 606, P.O. Box 2009
Toronto, Ontario
M4T 1M2
Toronto: (416) 973-8480
Elsewhere: 1-800-387-0733
(toll free in province)

Manitoba

- Energy Information Centre
Department of Energy and Mines
Government of Manitoba
117-234 Donald Street
Winnipeg, Manitoba
R3C 1M8
(204) 945-4154
- Energy, Mines and Resources Canada
Main Floor
112 Osborne Street S.
Winnipeg, Manitoba
R3L 1Y5
Winnipeg: (204) 949-4266
Elsewhere: 1-800-542-8928
(toll free in province)

Saskatchewan

- Energy, Mines and Resources Canada
S.J. Cohen Building
119 — 4th Avenue South
Suite 706
Saskatoon, Saskatchewan
S7K 5X2
Saskatoon: (306) 975-4532
Elsewhere: 1-800-667-9712
(toll free in province)

Alberta

- Energy, Mines and Resources Canada
Grandin Park Plaza
22 Sir Winston Churchill Ave.
2nd Floor, Room 200
St. Albert, Alberta
T8N 1B4
St. Albert: (403) 420-4035
Elsewhere: 1-800-222-6477
(toll free in province)

British Columbia

- Energy, Mines and Resources Canada
Room 200, 100 West Pender St.
Vancouver, B.C.
V6B 1R8
Vancouver: (604) 666-5863
Elsewhere: 112-800-663-1280
(toll free in province)

Northwest Territories

- Energy Conservation Division
Department of Public Works and Highways
Government of the Northwest Territories
Yellowknife Centre, 5th floor
Yellowknife, NWT
X1A 2L9
(403) 873-7203
- Energy, Mines and Resources Canada
Precambrian Building
10th Floor
4922 — 52nd Street
Box 68
Yellowknife, N.W.T.
X1A 2N1
Yellowknife: (403) 920-8475
Elsewhere: Zenith 06068
(toll free in territory)

Yukon

- Energy Branch
Department of Mines and Small Business
Government of Yukon
P.O. Box 2703
Whitehorse, Yukon
Y1A 2C6
(403) 667-5382
- Energy, Mines and Resources Canada
2078 — Second Avenue
Whitehorse, Yukon
Y1A 1B1
Whitehorse: (403) 668-2828
Elsewhere: Zenith 06068
(toll free in territory)

Refer in each case to:
"ENEROPTIONS Materials"